VOLUME XXII NUMBER 6

BOTANICAL GAZETTE

DECEMBER 1896

A RUST AND LEAF CASTING OF PINE LEAVES.

BEVERLY T. GALLOWAY.

(WITH PLATES XXII AND XXIII)

INTRODUCTION.

SOMETHING over five years ago the writer briefly described a Coleosporium,[1] or rust, occurring on the leaves of *Pinus Virginiana*, the scrub or Jersey pine.[2] The rust was found in considerable abundance on many trees, and owing to its interesting habits and its effects on the host, it was made the subject of more or less extended studies during the spring, summer, and autumn of 1891. In 1892 some additional investigations were made, this work being mainly a comparative study of the anatomy and physiology of healthy and diseased trees. In 1893 and 1894 some of the previous work was repeated and additional points in regard to the life history of the fungus and its effects on the host were brought out. Last year (1895) further studies were made. In these studies special attention was given to the shedding or casting of the leaves, a phenomenon which is known to follow the attacks of a number of fungi, and which it was thought of interest, in this case at least, to explain if possible.

[1] The systematic position of this fungus may be questioned, but as this is a matter of minor importance in the present paper it may be allowed to stand provisionally with the Coleosporiums.

[2] A new pine leaf rust, Jour. Mycology 7: 44. 1891.

I am indebted to Mr. Albert F. Woods for much assistance in the later stages of the work, and to Mr. Theo. Holm for a number of the anatomical drawings, and aid in finishing my own figures.

DISTRIBUTION OF THE HOST AND PARASITE.

Pinus Virginiana is a native of the eastern United States, being found in considerable abundance from central Pennsylvania southward to middle Georgia and westward to western Kentucky and Tennessee. Under favorable conditions the tree attains a height of 20 to 30^{m}, with a trunk 25 to 75^{cm} in diameter. In the District of Columbia and country immediately adjacent this is the most common species of pine, many of the old fields and waste grounds being overgrown with trees ranging in height from 3 to 5^{m}. It is on these that the Coleosporium is usually found, the parasite as a rule being especially prevalent on trees 2 to 4^{m} high.

The fungus has been found in more or less abundance in the District of Columbia, Maryland, and Virginia, and has also been collected by the writer on Lookout Mountain, in Tennessee, and at Asheville, N. C. No attempt has been made to collect it elsewhere, but there is no reason to doubt its occurrence wherever the host is found. Although careful examinations have been made the Coleosporium has never been seen upon any other host but the one under consideration.

APPEARANCE OF AFFECTED TREES.

During the winter the leaves of Pinus, in common with other evergreen plants, change color, the dark green fading out to a reddish yellow as the season advances.[3] As spring approaches the foliage again resumes its normal color, growing brighter as the conditions for growth become more favorable. In the early part of May, when the trees have fully recovered their normal

[3] For an account of the physiological changes involved in the winter coloring of evergreen leaves, together with a review of the literature on the subject, see G. HABERLANDT: Untersuchungen über die Winterfärbung ausdauernder Blätter, Sitzungsber. d. Acad. d. Wiss. zu Wien **72**: —. Ap. 1876.

color, those affected by the Coleosporium may be readily detected for perhaps 100^{m} or more by the pale yellowish hue of the leaves and the general thinness of growth. An examination of the affected trees shows that the yellowish color is due to the effects of the fungus, which is confined almost entirely to or near the tips of the needles formed the previous season. The thin appearance is owing largely to lack of leaves, those on the tree being mainly of the previous year's growth, all the others having prematurely fallen.

The changes in the host and parasite which precede the effects noted will now be discussed, attention being called first to some of the anatomical and physiological questions connected with the normal leaves, in order that what is said in regard to the effects produced by the fungus may be better understood.

ANATOMY OF THE NORMAL MATURE LEAF.

The leaves of *Pinus Virginiana* are as a rule borne in pairs. They are of a bottle-green color,[4] vary in length from 2.5 to 7.5^{cm}, and are nearly semicircular in outline, the dorsal side being curved and the ventral nearly flat. Cross sections of numerous leaves from trees grown under varying conditions show that the needles are nearly the same size throughout, namely, from 0.60 to 0.62^{mm} in diameter. Transverse sections of the leaf show that it is divided into three well-defined regions, namely, cortical, mesophyll, and fibro-vascular (*fig.* 1).[5] The cortical region occupies the periphery, and varies in thickness and structure according to the part of the leaf under observation; the part of the tree, with respect to sun and shade, from which the leaf is taken; and the condition of the soil, as regards moisture, where the tree is grown.

The cortical region is separable into three parts: (1) the epidermis, consisting of thick-walled cells quite regular in size

[4] ROBERT RIDGEWAY, Nomenclature of colors, 1886.

[5] ARTHUR, BARNES, and COULTER: Handbook of Plant Dissection, 1886; also COULTER: Synopsis of the North American pines based upon leaf anatomy, BOT. GAZ. 11: 258, 259. 1886.

and shape, the outer walls being strongly cuticularized (*fig. 2, ep*); (2) thin-walled stereomatic cells (*fig. 2, st*); and (3) thick-walled stereomatic cells (*fig. 2, st*). Both the thin-walled and the thick-walled stereomatic cells give the characteristic reaction for lignin with thallin sulfate, phloroglucin, and anilin sulfate.[6]

Neither the thick-walled nor the thin-walled stereomatic cells occur with any great degree of regularity in the cortical region. Frequently only the thin-walled cells are present, and then again there may be a definite layer of thin-walled cells next to the epidermis proper, with scattering thick-walled cells beneath. The more common arrangement is that in which both thick-walled and thin-walled cells are indiscriminately mixed, the whole forming a ring of tissue, which gives strength and rigidity to the needles.

At various points the stereomatic tissue is interrupted by the stomata (*fig. 2*). These occur on both sides of the leaf and are generally considerably depressed, as is the case with the other pines and plants having thick epidermal parts. The stomatic furrows are filled with a waxy substance, which probably plays an important part in preventing the entrance of fungi, and also, as Wilhelm[7] has pointed out, serves as a check to transpiration.

The mesophyll region occupies the median portion of the leaf, occurring in a zone which varies in thickness from 200 to 300 μ. The cells composing it are large and thin-walled, and contain, among other things, chlorophyll, starch, and the usual contents of assimilative tissue. In cross-sections the cells are seen to be nearly polygonal in shape and joined more or less closely in rows arranged at right angles to the cortical region. The number of rows vary according to the conditions under which the leaf is grown, those in intense light having, as Stahl;

[6] BEHRENS: Tabellen zum Gebrauch bei mikroskopischen Arbeiten, 1892.

[7] Ueber eine Eigenthümlichkeit der Spaltöffnungen bei Coniferen, Ber. d. deutsch. Bot. Ges. 1: 325. 1883.

[8] Ueber den Einfluss der Lichtintensität auf Structur und Anordnung des Assimilationsparenchyms, Bot. Zeit. 38: 868. 1880.

has shown, a greater proportion of assimilative tissue than those grown in the shade. The cells of the tissue under consideration are, in almost every case, provided with peculiar infoldings (*fig. 3*), hence the name *Armpallisadenzellen*, adopted by Haberlandt, Strasburger, and others.

In longitudinal sections the rows of mesophyll cells are seen to be separated by more or less space, which often extends without interruption from the cortical to the fibro-vascular region (*fig. 4*). The infoldings are not easily distinguishable in sections of this kind, but are usually seen as apparent partitions, and in some cases do not appear at all.

Within the mesophyll region and completely surrounded by the cells composing it occur the two resin ducts. The ducts are nearly opposite each other, being placed about equidistant from the radius of the leaf. They are cylindrical, completely inclosed by a sheath of thick-walled stereomatic cells arranged in a single row, and are lined with thin-walled epithelium (*fig. 5*). The central portion of the leaf is occupied by the fibro-vascular region. Separating this from the mesophyll is a closed sheath, the endodermis of Oudemans.[9] This consists of a single row of more or less suberized, elongated, thin-walled cells, closely joined at the horizontal or oblique ends (*fig. 6, end*). The walls also contain lignin, as shown by staining with indol.

Within the endodermis occur the mestome bundles (two in number), tracheids, and fundamental tissue, the latter consisting of thin-walled parenchymatous cells. The orientation of the bundles is normal, *i. e.*, the hadrome is directed toward the center and the leptome toward the periphery (*figs. 1* and *7*).

LIFE OF NORMAL LEAVES.

The length of time the leaves live varies according to a number of conditions, the most important being the age and size of the tree and cold and drouth. On trees 15 to 20^{m} high, growing in good soil, leaves may remain on three, four, and even five

[9] Ueber den Sitz der Luftwurzeln der Orchideen, Abhandl. d. Acad. Amsterdam, Math. Phys. Klass. 9: —. 1861.

years. On comparatively young trees, 1 to 5^{m} high, the leaves may fall the second year. As a rule the average length of life may be placed at two years, that is, the leaves fall the summer or autumn of the second year. The time of falling, however, is not constant, as in some cases it may occur in the spring.

Numerous physiological changes take place during the period of from three to four weeks preceding the actual fall of the needles. First, the contents of the mesophyll cells gradually disappear, this being accompanied by a change in the color of the needle from green to reddish yellow. With the disappearance of the chlorophyll bodies, large oil globules appear in the mesophyll cells, and at the same time the walls of the latter become considerably thickened. Not until a week or ten days before the pair of needles fall is it possible to make out clearly the separative layer, the formation of which does not materially differ from that which takes place in most of the ordinary deciduous plants. In case of high wind or rain the leaves are frequently blown or knocked off before the separative layer is fully developed. Usually they remain on, however, until the process is fully completed, after which they dry up and fall from their own weight.

DEVELOPMENT OF THE FUNGUS AND ITS EFFECTS ON THE TREE.

An examination of an affected tree early in April shows on the needles of the previous year's growth pale yellowish bands, which vary in width from 2 to 4^{mm}. The discolorations seldom if ever extend to the extreme tip of the needle, this point as a rule remaining normal in color up to a certain time, despite the action of the fungus on the tissues below. Close examination of the diseased areas at this time reveals numerous brown and yellow pustules, which are only slightly elevated above the surface of the leaf (*figs.* 8 and 9). The pustules are the sori of the fungus, and mark the point where the spores will eventually break through. The sori vary in width from 0.2 to 0.5^{mm}, and are from 0.2 to 1^{mm} long. As the season advances the sori increase in size, many of them coalescing and forming long

bands parallel to and including, of course, the rows of stomata. The color of the diseased part of the leaf and the sori also becomes brighter yellow. By the middle of May, if the season is a normal one, the sori reach their full development, the color at this time being bright orange. As long as the weather is dry there is little change in the sori, but at the first rain or fog they rupture the cortical tissue, forming long, bright orange red, waxy, or granular elevations, 0.5 to 1^{mm} high. If the weather continues wet the sori retain their bright color, but upon close examination they are seen to be overrun with minute cobweb-like threads. Lack of rain causes these threads to disappear, but for a time at least the sori lose none of their characteristic color, size, or shape. Rain or fog will again cause the sori to swell, to become granular and waxy, and to show the growth of colorless threads, as already described. This alternate drying up and breaking out of the sori may continue two and sometimes three weeks, or it may continue but a few days, the length of time varying with climatic conditions and different trees. In case of a spell of a week or more of rainy weather the sorus will often complete its development and collapse completely as soon as the sun comes out for a few hours. Occasional rains, followed by several days of fair weather, prolong the life of the sorus in all cases.

Under ordinary conditions of humidity the sori for the most part complete their development by the middle of June, or about one month after they first break through. The diseased portion of the leaf at this time assumes a brownish hue and becomes more or less shrunken. The sori also turn brown, collapse, and soon dry up entirely. The tissues below and immediately adjoining the diseased areas now begin to turn yellow, this discoloration gradually extending downward until the whole leaf is involved.

If both needles are affected by the fungus both change simultaneously from the normal green to yellow. If, however, only one of the needles is affected the change extends from the tip downward on the affected one and from the base upward on

the other. From yellow there is a gradual change to brownish red, the tissues in the meantime becoming considerably shrunken. Finally the pair of needles fall, this often being hastened by rain, wind, or any sudden jarring or shaking of the tree. In from three to six weeks after the fungus breaks through the tissues most of the leaves have fallen. Trees badly affected are the first to shed their leaves, defoliation being very rapid and often completed before the last-formed needles have attained full size.

MICROSCOPIC STUDIES OF THE FUNGUS.

Turning our attention to the fungus itself and the manner in which it produces the changes described, a microscopic study of transverse and longitudinal sections through the pale yellow spots found early in April shows, growing between the cells composing the mesophyll region, a coarse, colorless, septate mycelium, containing numerous granules and vacuoles (*figs. 10* and *11*). The mycelium is confined wholly to the intercellular spaces of the mesophyll region. It never penetrates the walls of the mesophyll cells, but in many cases adheres very closely to the latter, producing changes in the cell contents which will be described as we proceed. Wherever it comes in contact with the cells composing the endodermis or the resin ducts it is effectually turned aside (*fig. 18*). A comparison of the diseased and healthy tissues at this time will show no essential difference so far as thickness and size of cells are concerned. In unstained sections the entire cortical and fibro-vascular regions, as well as the resin ducts, appear intact. The contents of the mesophyll cells of the diseased leaf, however, are seen to be disorganized. The chlorophyll bodies have disappeared and in their place many large oil globules are seen. In the healthy cells the chlorophyll bodies are numerous and distinct, while there are few or no oil globules. In the cells around some of the stomata of the diseased leaf the contents are not only disorganized, but are yellow and partially opaque. The V-shaped cell below the stoma is usually not involved, but those around, and especially below, show the change in a marked manner.

At certain points, which do not seem limited to any particular region, the mycelium pushes its way toward the cortical region, and between the latter and the mesophyll cells it begins to form a sorus or spore bed (*figs. 10* and *11*). This is effected by a continued interweaving of the mycelium, which at the same time becomes more septate and brown or orange yellow. As the spore beds increase in size the cortical region is pushed upward, thus giving rise to the pustules already described. With increasing age the spore beds become more compact, so that by May 10 to 15, or just before they break the tissue, they show, beneath the cortical tissue, compact rows of rounded septate bodies (*fig. 11*), the sporophores.

The sporophores are formed in the following manner: The hyphæ, which push toward the surface, begin to enlarge at their tips (*fig. 12*). Soon a septum forms just below the swollen portion, the result being the formation of a more or less rounded cell. By successive abjunction other cells are formed, until the sporophores appear in compact rows, as already described. When mature and the proper conditions of moisture are present the upper cell of each sporophore gives rise to a mass of gelatinous substance, which has no very definite structure, so far as can be ascertained from a study of transverse sections (*fig. 13*). It is the sudden development of these gelatinous masses that ruptures the cortical tissue, thus bringing the sorus into direct contact with air, moisture, and more intense light. In from three to four hours after the cortical tissues are ruptured, cylindrical bodies, which later develop into teleutospores, begin to shape themselves out of the mass of gelatinous material (*fig. 14*). These bodies soon begin to turn yellow and in a short time their walls may be definitely made out. The outer walls of each teleutospore consist of an enormously thickened, colorless, gelatinous membrane, and it is the massing of these membranes that gives to the young sori the characteristics already described. At this time it is very difficult to make out the transverse walls separating the teleutospores. Treatment with potash solution and with nitric acid, however, brings these out distinctly.

In from four to ten hours after the sorus breaks the cortical tissues the teleutospores attain full size. By this time the gelatinous membrane has mostly disappeared, and consequently the contents and septum separating each teleutospore is plainly apparent.

The teleutospores are arranged in rows of from two to four, one above the other. They do not separate, however, from each other, and it is with some difficulty that they are removed from their attachment in the sorus. When fully mature the compound teleutospores vary in length from 75 to 150μ and in diameter from 18 to 30μ.

The spores begin to germinate as soon as mature, the process taking place only in water or saturated air. The first evidence of germination is a small protuberance, which may appear at the apex or at any of the septa. Usually the topmost cell germinates first and the others follow in the order of their arrangement (*fig. 14*). The protuberance rapidly elongates into a tube, which may grow to a length several times that of the compound spore, or may remain quite short. The length, however, depends largely on the amount of moisture present, the tube attaining its greatest length if the spore is in water and its shortest if in moist air. The contents of the spore flow out into the tube, the greater portion being near the tip and the rest more or less in groups throughout its entire length. The vacuoles in the cell flow out with the contents and may usually be found at the upper extremity of the tube.

When the tube attains its full length, this, as already indicated, depending in large part on the amount of moisture present, it begins to swell at the tip (*fig. 15*). The swelling rapidly increases in size and at the same time the walls directly below it become more or less constricted. At this point a septum is formed, this process usually lasting not more than twenty-five or thirty minutes. The body thus cut off by the septum is the sporidium, which now begins to increase in size and assumes various shapes. Occasionally the sporidium will send out a germ tube while still attached to the supporting promycelium.

Usually, however, the sporidium separates from the promycelium in about thirty or forty minutes after the partition forms, and then almost immediately begins to germinate by sending out a short, thick germ tube. All or nearly all the contents of the sporidium flow into the germ tube. Occasionally this tube grows out to a considerable length, cutting off a secondary sporidium (*fig. 16*) upon its free end in much the same way that the original was formed.

After the spore germinates the walls remain turgescent for a short time, and then collapse and dry up, the spore in the meantime becoming perfectly colorless. The entire contents of the cell seem to be used up in the formation of the promycelium and the sporidium, and if this is not the case the formation of secondary sporidia goes on until there is no protoplasm left.

Germination as here described takes place in nature only when the leaves are wet, the spores themselves seldom if ever escaping from the sorus. The sporidia, however, when cut off from the promycelia either fall or are washed down to the leaves below or to the ground, where they may be found in great abundance after a damp or foggy night. In all infection experiments, which will be referred to later, the sporidia were obtained in abundance by placing sterilized Petri dishes under the diseased branches confined in a moist chamber. After several hours an abundance of sporidia may be obtained from the dishes.

INFECTION OF THE HOST.

On closely examining the diseased trees the sporidia may be found on the young leaves, which at this time are just beginning to show their tips. The usual place for lodgment is between the tips of the two young needles, which at the time the spores are forming project about 0.33^{cm} above the sheath which incloses them. The needles are slightly spread open, thus allowing a small drop of water to be retained. The water that collects in this way drips from the old leaves above, upon which the spores and sporidia are being formed. In dropping down it carries the sporidia with it, depositing the latter in a

position where they may, under the very best conditions, germinate and infect the young needles.

For several years the time of the appearance of the spores and young leaves has been watched, and in every case a most remarkable similarity in dates has been observed. If the leaves are late or early in coming out the spores will be correspondingly late or early. This is exceedingly important in the economy of the fungus, for it has been proved by successive infections that a difference of but two days in the age of the leaf will enable it to resist the fungus. Infection, in other words, must take place when the parts of the needles are from 0.33 to 0.66^{cm} long (*fig. 19 a*, too old; *b*, proper age), otherwise the cortical region will be developed to such an extent that the germ tubes from the sporidia cannot force their way through.[10]

The needles are infected wholly by means of the germ tubes boring through the cortical tissue before the stereomatic, thick-walled cells have formed. These tubes make their way to the mesophyll region, where they immediately begin to lengthen, in eight or ten days assuming all the characteristics of the mycelium already described. The orifice, however, through which the germ tube enters the leaf, soon disappears, leaving no trace of the manner in which the fungus reaches the mesophyll region. In about three months, or by the middle of August, the fungus has developed to such an extent that its presence may be determined by the condition of the tips of the needles. Pale yellowish spots may be seen at these parts, and microscopic examination of the tissue reveals the mycelium growing in all directions between the cells of the mesophyll region. As the season advances the spots or bands become more prominent, and by the middle of November, or even earlier, pustules, indicating the formation of sori, begin to appear. By the first of April, or ten

[10] For the sake of brevity the details of the experiments are omitted. Briefly, in this case one hundred pine branches were bagged with paper bags, the work being carried on for two successive years. From time to time a bag was removed and the young leaves received a small drop of water containing germinating sporidia, after which the leaves were marked and the bag replaced. About 75 per cent. of the inoculations made when the leaves were the proper age were successful.

months after infection, the fungus is found in the condition already described. A month or six weeks later it again produces spores, thus completing its cycle of development in one year.

CASTING OF THE LEAVES AND ITS CAUSE.

As already pointed out, we have in the case of the *Coleosporium* a fungus producing first purely local injuries, which later result in the death and casting of the leaves. The phenomena involved in this process may now be considered. An examination of the diseased leaves soon after the sori collapse shows that the conductive tissue has not been injured at all, the endodermis being intact and the fibro-vascular bundles abundantly able to conduct water. That they do this is evident from the fact that, even though the mesophyll invaded by the fungus be brown and shriveled, the tip of the leaf above this part remains green for a considerable time. In the tissue where the fungus has been at work there are large rifts which extend unbrokenly to the endodermis. The cell contents of the mesophyll region immediately below the part attacked by the Coleosporium, and where there is no mycelium at all, are broken up, showing that changes are taking place which are not directly attributable to the fungus. These changes are manifested externally by the yellowing, already described, which gradually extends downward until both needles are involved. Even before this the separative layer begins to form and in a week or ten days more the pair of needles fall. Of course, the fungus itself is the primary cause of the leaf fall, but that it acts only as a power to set other causes at work was early shown by cutting off the affected portions of the leaves. In every instance this treatment caused the leaves to remain on the tree and perform their functions in a normal manner until death came from old age. In all cases, however, it was found necessary to make the cuts through normal green tissues, *i. e.*, below the point where the yellowing showed. If only one needle was allowed to become partly yellow and the cut was made through the discolored por-

tion the changes eventually leading to the fall of the leaf were not checked at all.

It was thought that possibly the fungus by its action might have produced chemical changes in the cell contents and that these changes alone were sufficient to produce the effects described. It was reasoned, however, that if there was anything in the nature of a ferment present it should be capable of propagating itself when brought in contact with the cells of healthy pine leaves. To obtain a definite answer to this question a series of experiments were made, which need not be entered upon in detail here. Suffice it to say that after more than two hundred trials with juices from diseased leaves rubbed on broken and unbroken tissues of healthy foliage and brought into contact with the healthy cells in other ways, not a single case of leaf casting or leaf yellowing occurred.

It is unnecessary to go over the ground which led to the belief that the changes, as already described, were due to excessive loss of water. The large rifts in the cortical and mesophyll regions, the uninjured conductive tissue, and the fact that no cork layer, cutting off the injured portion of the leaf, was formed, all pointed to a derangement of the water supply.

To obtain information upon this matter a number of experiments were made, some of which will now be described. The first experiments were with cobalt paper[11] to determine the relative evaporation of water from the parts affected by the fungus and the uninjured portions. The tests were made before and after the fungus had broken through, the usual method being to fasten strips of dry paper to the leaves by means of glass slides. It was found that before the fungus broke through the diseased areas lost less water than the healthy portion of the leaf. This was due to the permanent closing of the stomata over the diseased areas, owing to the action of the fungus on the adjacent tissue. The fact that the diseased spots lost less water than healthy portions of the leaf explains why such spots remain

[11] For a discussion of the cobalt method, see STAHL, Bot. Zeit **52**: 117–145. 1894; reviewed in BOT. GAZ. **21**: 26–33. 1895.

green longer than other parts when a branch is cut from the tree and allowed to die through lack of water.

As soon as the Coleosporium has ruptured the cortical tissues evaporation rapidly increases, until it exceeds that from a corresponding area of healthy tissue. This was proved by the

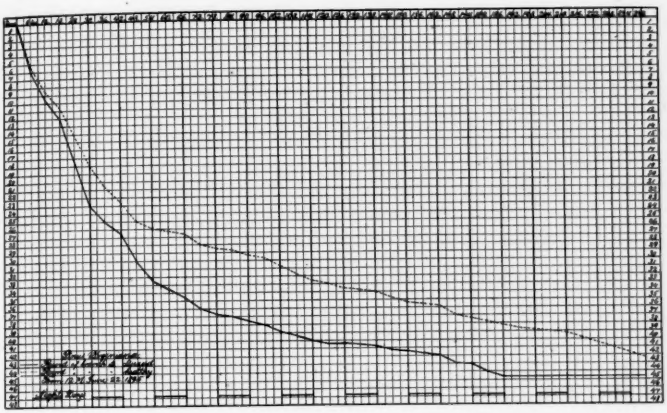


FIG. 1. Diagram showing evaporation from diseased and healthy branches.

cobalt paper test and also by the following experiments: Two branches, as nearly alike as possible, were secured and cut off under water and the cut ends sealed into a flask of normal culture solution, so that no water could escape except through the leaves. Each branch had 206 leaves. The leaves on one branch were healthy and on the other the Coleosporium had just broken through the diseased areas. Starting at 12 M. June 22, the curves in the accompanying diagram show the loss in grams in periods of six hours for ten days, as determined by a recording balance. The water supply was not as good as the dry air surrounding the leaves demanded. This lack of water was due to the accumulation of resin on the cut ends of the branches and the development in the same place of bacterial slimes. The unbroken line represents the loss from the diseased branch and the broken line the loss from the healthy

branch. It will be observed that the loss during the first forty-eight hours was rapid in both cases, namely, 25 gm from the healthy branch and 30 from the diseased. At the end of this time both the healthy and the diseased leaves showed an evident lack of water. This lack, however, was more marked in the diseased leaves, the tips of many of which were shrunken above the diseased area. This lack of water had caused the stomata of both the healthy and the diseased leaves to close as far as possible, thus cutting down the loss through them to a minimum. During the next forty-eight hours the healthy branch lost 4.5 gm while the diseased lost 8 gm. It was evident that from this time the leaves were able to obtain very little if any water from the stem. During the next three periods of forty-eight hours each the healthy branch lost 5, 4.5, and 2.5 gm respectively, while during the same periods the diseased branch lost only 3.25, 3, and 0 gm. The leaves of the diseased branch were completely dry at the end of 186 hours, while the healthy plant was not yet dry at the end of 240 hours, but was still losing at the rate of 1.5 gm per day. The more rapid drying out and death of the diseased leaves than of the healthy is therefore evident. As a further evidence of this the following experiment may be cited:

Six pairs of leaves, three of which were diseased and three healthy, were removed from the same branch and immediately cemented into a piece of cork to keep them from tipping over. Weighings were then made at given periods, with results as shown in the accompanying diagram, the broken lines representing the diseased and the unbroken the healthy leaves. It will be seen that the average loss for the healthy leaves for the first twenty-four hours was about 5 mg, while from the diseased leaves it was 16 mg. This rate of loss continued nearly constant for the healthy leaves for 174 hours, while the loss from the diseased leaves kept gradually diminishing. At the end of 120 hours the healthy had lost about 24 mg and the diseased 32 mg. The latter were now becoming quite dry, so that during the next twenty-four hours they lost an average of only 3 mg, while the healthy lost about 11 mg. At the end of this period (174 hours) the diseased leaves were air-dry, and

being hygroscopic their weight increased and diminished with the ordinary changes in atmospheric humidity. The healthy leaves continued to lose at a diminished rate and at the end of 288 hours were not yet dry.

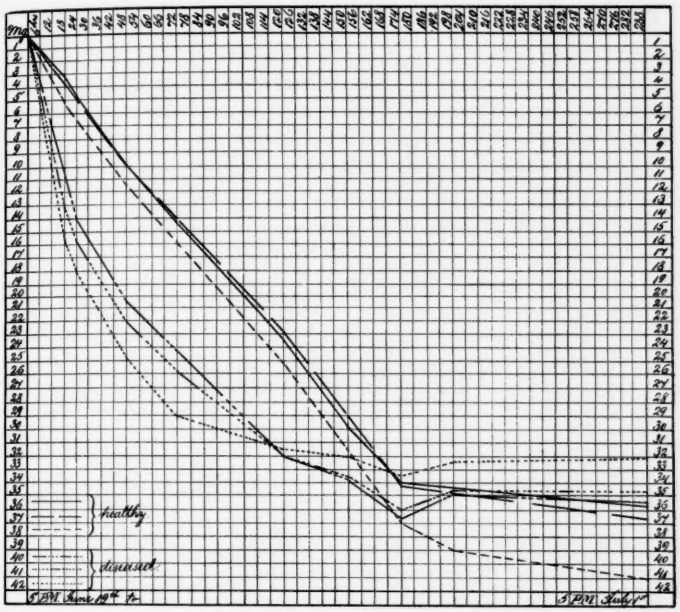


FIG. 2. Diagram showing evaporation from diseased and healthy leaves.

One additional experiment in this connection may be of interest. It was carried on during the casting of the leaves for three successive years and each time with practically the same results. Twenty-five small branches, containing about fifty pairs of leaves each, were cut during the night from a diseased tree, and immediately the cut end of each branch was pushed through a small hole in a cork and into a bottle containing water. After being fastened into the neck of the bottle, the cork and branch were sealed with paraffin, so that no water could escape except

through the leaves. Twenty-five healthy branches, taken from the same tree which furnished the diseased ones, were prepared in a similar manner. All the bottles were then brought into the laboratory and weighed twice daily for ten days. At the end of this time the branches and leaves were weighed and the amount of water evaporated per gram of dry weight was calculated. It was found that the diseased leaves evaporated approximately one-fifth more than the healthy, these results holding good through all the experiments, as will be seen by a study of the preceding diagrams.

The fact that cutting off the diseased parts of the leaves prevented them from falling has already been pointed out. It was assumed that the removal of the injured portions stopped the excessive evaporation and enabled the leaf to heal the wound made by the cut, which it could not do in case of the fungus. To prove this a number of experiments were made, of which the following is an example:

Twelve pairs of fresh leaves were selected, six pairs being diseased and six healthy. These were divided into four sets of three pairs each. Set no. 1 (healthy) had one-half inch cut from each leaf and the tips charred with red hot glass to prevent an excessive loss of water and turpentine. After charring, the tips were coated with a varnish, which prevented the entrance of fungi and slightly reduced the evaporation of water from the cut ends. Set no. 2 (diseased) was treated in the same way, the diseased ends being removed. Set no. 3 were healthy uncut leaves and set no. 4 diseased uncut leaves. All these sets were weighed at given periods and the loss in weight determined. The results are shown in the accompanying diagram.

During the first twenty-four hours the healthy cut leaves lost 9^{mg}, the diseased cut and the healthy uncut exactly 7^{mg} each, and the diseased uncut 11^{mg}. The same relative loss held good through the next forty-eight hours.

The ends of the healthy cut leaves lost water more rapidly than the ends of the diseased cut leaves, making the loss approximate more closely to that of the diseased uncut leaves. The

ends of the diseased cut leaves were more securely closed, so that they dried out only a little more rapidly than the healthy ones. This experiment shows that cutting off the diseased parts reduces evaporation to the normal amount. It appears there-

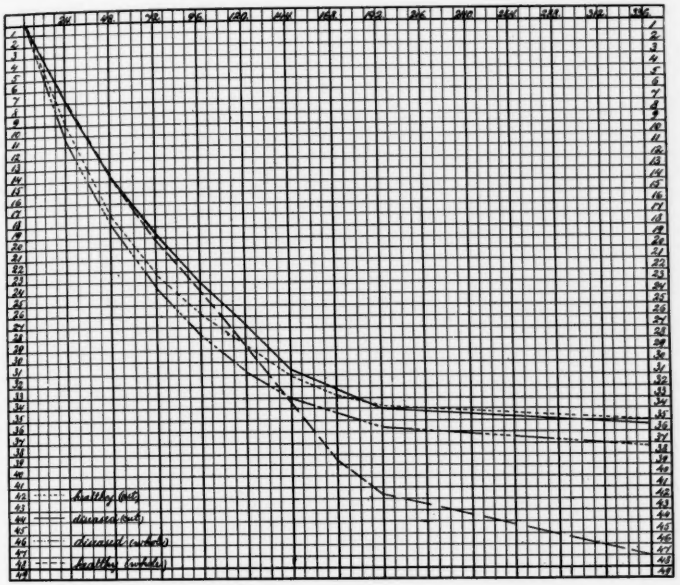


FIG. 3. Diagram showing evaporation from healthy and diseased leaves from which the tips had been cut.

fore that as soon as the fungus ruptures the cortical tissues of the leaves normal evaporation is increased about one-fifth. The physiological significance of this fact is great, as it affects the entire economy of the plant.

Without entering upon a discussion of all the processes involved it may be said that this constant loss of water from the leaf cannot be supplied by the conductive tissue. Drawing on the reserves of water in the cells is therefore necessary, and this is followed by loss of turgidity, cessation of growth, and finally

death. The strain is so gradual, however, that the changes preceding death do not differ from those which take place in a dying leaf after having lived its allotted time.

SUMMARY.

To recapitulate, the investigations here described have shown that:

(1) *Coleosporium pini* occurs abundantly in Maryland, Virginia, and the District of Columbia, attacking only *Pinus Virginiana*.

(2) It requires twelve months to complete the development of this fungus, and during a large part of that time it does not seriously interfere with the functions of its host.

(3) The fungus is disseminated by means of sporidia, which develop only during wet weather.

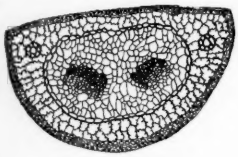
(4) From the leaves on which they are borne the sporidia are washed or drop to the young needles just showing their tips, which they infect. No evidence of this infection, however, is apparent for two or three months.

(5) Regardless of the season, there is a marked similarity in the time of the appearance of the sporidia and the time of the appearance of the young leaves.

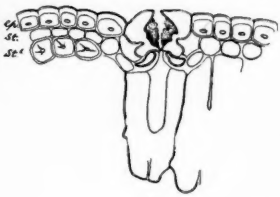
(6) Before the fungus ruptures the cortical tissue evaporation from the diseased areas is less than that from healthy parts of the same leaf. This is due to the permanent closing of the stomata and may result in keeping the diseased parts alive longer than the healthy in case the leaf or branch is removed from the tree.

(7) As soon as the fungus ruptures the tissues evaporation is increased about one-fifth above the normal. In consequence of this the reserve water in the cells is gradually used up. This is followed by loss of turgidity and other physiological changes which lead to the gradual death and casting of the leaves.

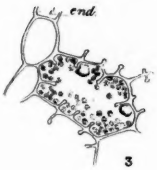
U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.,



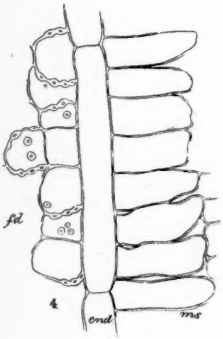
1



2



3

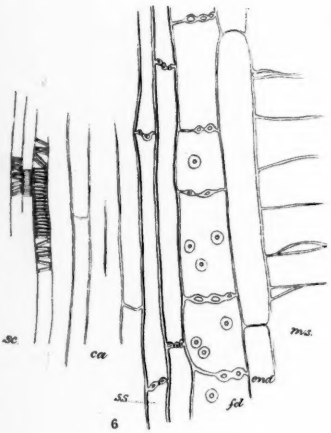


4

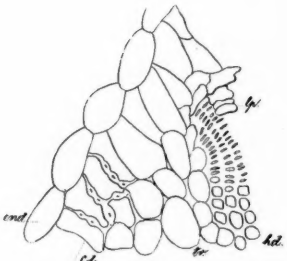
5

8

9

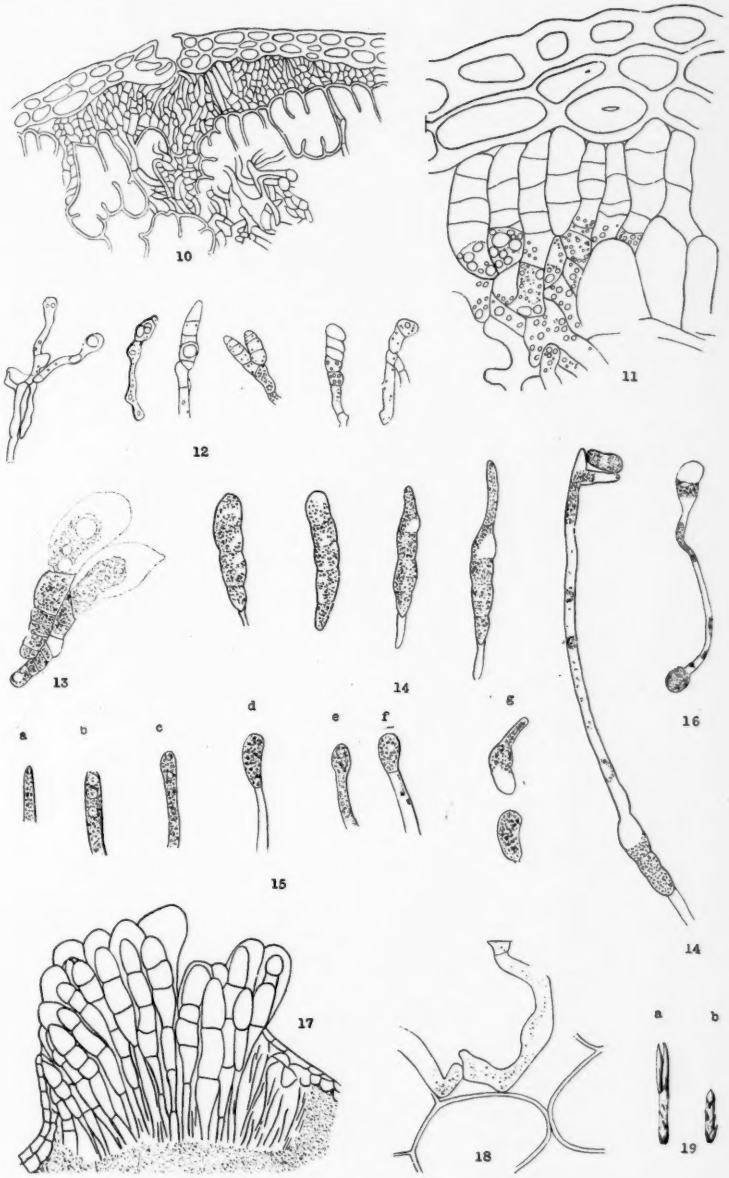


6



7

GALLOWAY on RUST and CASTING of PINE LEAVES.



GALLOWAY on RUST of PINE LEAVES.

EXPLANATION OF PLATES XXII AND XXIII.

FIG. 1. Cross-section of leaf of *Pinus Virginiana*, showing cortical, mesophyll, and fibrovascular regions.

FIG. 2. Cortical region and stoma; *ep*, epidermis; *st*, stereomatic thin-walled cells; *st'*, stereomatic thick-walled cells.

FIG. 3. Mesophyll cell and portion of endodermis, *end*.

FIG. 4. Longitudinal section of portion of leaf; *fd*, fundamental tissue; *end*, endodermis; *ms*, mesophyll cells.

FIG. 5. Resin duct.

FIG. 6. Longitudinal section of leaf; *ms*, mesophyll; *end*, endodermis; *fd*, fundamental tissue; *ss*, sieve tubes; *ca*, cambium; *sc*, scalariform vessels.

FIG. 7. Cross-section of a portion of leaf; *end*, endodermis; *fd*, fundamental tissue; *tr*, tracheids; *hd*, hadrome with scalariform vessels; *lp*. leptome.

FIG. 8. Branch of *Pinus Virginiana* showing Coleosporium on one year old leaves.

FIG. 9. Pair of leaves from the branch shown in *fig. 8*.

FIG. 10. Cross-section of pine leaf showing development of hyphæ.

FIG. 11. Portion of sorus of fungus showing sporophores and mycelium

FIG. 12. Various stages in the development of sporophores.

FIG. 13. Beginning of the formation of two spores.

FIG. 14. Mature spores and spores in various stages of germination.

FIG. 15. Development of sporidia, *a* to *g*.

FIG. 16. Sporidium forming a secondary sporidium.

FIG. 17. Section through a sorus showing mature spores.

FIG. 18. Mycelium turned aside by the endodermis, which it never penetrates.

FIG. 19. Two pairs of young pine leaves, *a* too old for infection, *b* the proper age for infection (both natural size).

THE PHILOSOPHY OF SPECIES-MAKING.[1]

L. H. BAILEY.

1. THE SPECIES-CONCEPTION.—It is probable that the forms of life have sprung from one common or original point. At all events, there seems to be a general series of convergent histories in organic nature, when one attempts to trace genealogies. These multitudes of forms seem to bear some definite and intimate relation to the circumstances under which they live and grow; in fact, they appear to have resulted from the splitting up and modification of the original plasma by means of the contest of numbers and the changes and diversifications in the physical characters of the earth. There are as many forms or kinds of life as there are diverse and disputed places upon the earth, and the forms no doubt are still, for the most part, slowly adjusting themselves to the continuing changes in the conditions in which they grow. We now have the best of reasons for believing that the organic creation is a plastic one, and that it will continue to be modified so long as it is possible for life to exist upon the globe. If the forms of life shall finally perish, the extinction will be preceded by a long process of diminution of virility coming as an adjustment to increasingly untoward conditions.

When *men* first began the serious study of the forms of life, they were still convinced that the creation is a congeries of objects which had come directly from the hand of the Creator, a collection or a patchwork of most curious things. The intellectual grasp of the creation was not yet comprehensive enough to suggest, to many minds at least, that the universe is one thing, one conception, a unity in method; the mind therefore rested upon the individual objects and logically exalted them into the sphere of units in the creation. In other words, the ultimate units, the entities, in organic nature were, to the early

[1] Read by title before The Botanical Society of America, August 1896.

naturalists, the things which were to be seen. If the forms of life were the entities, then the units must have one common designation; and the technical expression applied to them was the word *species*. To make names and descriptions for these units was really to know nature; so there arose a desire to make inventories of nature, and the organic creation was speedily cut up into coordinate units. All this resulted in a species of versification or paragraphing of nature; and it would not be unfair to say that, in this conception, the species is the organic paragraph.

The reader will now perceive that the two attitudes of mind which are sketched in these two paragraphs are antagonistic and incompatible. If one is true, the other is necessarily untrue. Evolution, as a method, is either true or it is not true. It cannot be half true. If evolution is true, then the forms of life are not the units or entities in the organic creation; they are the disjoined remaining results of the world-long process of elimination, the incidental outcomes of a vicarious history. In some lines of ascent, notably in the mammals, these forms are, to be sure, exceedingly well marked, but these only attest the more strongly to the survival of the most specialized types. In other words, there are no species as understood by Ray and Linnæus and Cuvier and the older naturalists.

It is unnecessary to argue for the truth of evolution before this constituency; although I suspect that there are still botanists who accept evolution as true only in those particular groups in which they can observe some direct evidences of it, without seeing that such limitation of its action is a denial of its universality and therefore of its truth as a principle. Yet I suppose that I should not meet strong opposition if I say that naturalists now regard species as the final, that is, the present, adjustment of forms of life to circumstances; and yet the greater number of naturalists seem still practically to look upon the species as the organic unit. Even the definitions in our latest and best lexicons insist upon the intrinsic merits of species. The *Century Dictionary* defines a species, in biology, to be "that which is

specialized or differentiated recognizably from anything else of the same genus, family, or order; an individual which differs, or collectively those individuals which differ, specifically from all the other members of the genus, etc., and which do not differ from one another in size, shape, color, and so on, beyond the limits of (actual or assumed) individual variability, as those animals and plants which stand in the direct relation of parent and offspring, and perpetuate certain inherited characters intact or with that little modification which is due to conditions and environment." The *Standard Dictionary* defines a species as "a classificatory group of animals or plants subordinate to a genus, and having members that differ among themselves only in minor details of proportion and color, and are capable of fertile interbreeding indefinitely." *Webster* is as follows: "In science, a more or less permanent group of existing things or beings, associated according to attributes, or properties determined by scientific observation." Stormonth's *English Dictionary* says that a species is "a group of individuals or objects sufficiently identical in all their natural qualities to justify the conclusion that they may have sprung from a common stock."

In all these definitions the idea of genetic continuity seems to be fundamental, and in this respect they are not greatly unlike the definitions which were current in pre-Darwinian times. They all seem to be descendants of Cuvier's conception that a species is "the reunion of individuals descended from one another, or from common parents, or from such as resemble them as closely as they resemble each other." This really amounts to little more than Linnæus' phrase, "We reckon as many species as there were forms created in the beginning."

Although we are driven to abandon the conception that the immediate forms of life are the units in the organic creation, we must nevertheless arrive at our knowledge of this creation by means of these forms. It is these forms which we take hold of when we study nature. They are the tangible objects with which we deal. Then they should be described and named; but the important point is that the forms of life serve as a convenient

means of classifying our knowledge of nature, and are not entities in themselves. Species are, therefore, a human contrivance, and the only value which the modern naturalist can attach to them, as such, is their temporary convenience as a means and vehicle of thinking and writing about the organic creation. They should be defined only in terms of classification, not in terms of structure and genealogy, that is, in terms extrinsic, not terms intrinsic. Modern naturalists have largely eliminated genealogy from the definitions of species, but I do not recall any who define it solely as a convenience of taxonomy. Huxley writes that "a species is the smallest group to which distinctive and invariable characters can be assigned." Haeckel's definition is one of the very best but is too indefinite to be workable. In his conception the word species "serves as the common designation of all individual animals or plants which are equal in all essential matters of form, and are only distinguished by quite subordinate characters." Unsatisfied with the current definitions, I defined species, in *Survival of the Unlike*, as "a term used to classify animals and plants, by designating or grouping together all those forms or individuals which are very much alike in taxonomic marks." But this is too indefinite to be of much use. As I now conceive of it, I should define a species as follows: *The unit in classification, designating an assemblage of organisms which, in the judgment of any writer, is so marked and so homogeneous that it can be conveniently spoken of as one thing.*

II. The Art of Species-making.—When we come to the practical application and use of the word species, we must admit that the more carefully we distinguish the forms of life, the smaller or narrower must be the assemblages to which, for reasons of perspicuity, we apply the word. The smaller the classificatory divisions, the more exactly can we speak of organic life. We elucidate our subject more by dividing it than we do by massing it. I therefore look with favor upon the tendency in some quarters to make specific names for forms which have heretofore been regarded as well marked varieties, although I

admit that it is easy to acquire the tendency to give specific names to forms which are of such small taxonomic importance that the student may be confused rather than enlightened by the subdivision. The remarks in this paragraph represent Asa Gray's later conviction, a position which he once summed up to me, with his characteristic forcefulness, in the remark that "species are judgments." I remember his saying to me, in effect, that he should consider the Atlantic Ocean to be a good distinguishing mark between certain species; that is, that forms which would scarcely be considered to be specifically distinct when occupying the same or coterminous areas might properly be called species if they were separated distinctly by great natural barriers. I am quite sure that he looked upon very similar forms in very unlike geographical regions as tending towards greater differentiation, and whenever it was possible, in perspicuous treatment, to draw fairly good characters of separation between them he thought that it was expedient to do so. In other words, Gray would not make quantitative characters supreme in his designation of species.

I would not for a moment make it a test of a species that there should be no intergradient forms. If the intermediate forms are so few that they do not seriously obscure the mental conception of the type, then all interests will be subserved by disregarding them for purposes of nomenclature. In fact, I should expect very few species of plants to be perfectly free from aberrant and entangling forms. The groups of plants are rare in which one can say that the types are unique. Soil, exposure, climate, contest with fellows, and a hundred incidental circumstances leave their impress upon the plant forms.[2]

If the making of species is an expediency, then it follows that it is not necessary, or even desirable, that we should search for obscure or anatomical characters with which to separate them. These characters belong to anatomy, physiology, embry-

[2] It would seem that some exception might be made to these remarks in the lucid genus Carex, for Britton, in describing a new species, was able to find "crucial proof of its distinctness." Bull. Torr. Bot. Club **22**:220.

ology, and the like, not to taxonomy. At all events, it seems to be clear that the species-division will be useful in proportion as it is founded upon obvious and easily ascertained attributes.

My own convictions respecting the art of species-making may be illustrated by a concrete example, which I have elsewhere published.[3]

"If this position is well taken, it follows that the naturalist should not describe new species with the idea of adding another item or organism to the inventory of nature, but for the purpose of classifying and clarifying our knowledge of the kind and extent of variation which the given group presents. A new species, therefore, is made simply for convenience's sake. In very variable groups it is perfectly justifiable to make species when it is known that occasional forms are intermediates, if thereby we are enabled to understand the relationships of the various forms more clearly. This is particularly true in narrow groups which have many forms of varying taxonomic importance. An illustration may be taken from the genus Carex. The *echinata* group contains four more or less coordinate main types, the *echinata* proper of the Old World, and three types in the United States. It has been the fashion to throw these all together into a composite species, calling it *Carex echinata*. In this arrangement, the subgroups or sub-forms do not stand out clearly, and it is impossible to contrast them forcibly. Moreover, the characters which separate the most marked sub-forms are of as great or even greater classificatory importance than characters which are used to separate *Carex echinata* itself from its fellow species. The old arrangement might be graphically presented as follows:

"*Carex echinata.*
  Group B.
    Subgroup *a*.
    Subgroup *b*.
    Subgroup *c*.
  Group C.
  Group D.
    Subgroup *a*.

"This classification, from a taxonomic standpoint, is untrue, for, as Carex species go, groups B, C, D are coordinate with *C. echinata*, and not subordinate to it. The mere fact that there are now and then intermediate forms between these various groups should not deprive us of the privilege of expressing the taxonomic facts. In nearly every instance specimens can be clearly referred to one or the other of the groups by one who is familiar with

[3] Survival of the Unlike, 134, 135

them; but so long as the various groups are represented to be of minor and variable importance — as the above arrangement does represent them to be, to a botanist's mind — so long will they remain to be comparatively little distinguished and understood. Consequently I have erected (Bull. Torr. Bot. Club 20:422) the four groups into coordinate species, as follows:

A. *Carex echinata.* Old World.

B. *Carex sterilis.* New World.

a. var. *excelsior.*

b. var. *cephalantha.*

c. var. *angustata.*

C. *Carex Atlantica.*

D. *Carex interior.*

a. var. *capillacea.*"

III. The Hybridity Corollary.—Intermediate forms are the most confusing and disturbing elements in species-divisions. These forms may be (*a*) normal intergradients, (*b*) unusual or sportive aberrations, or (*c*) hybrids. The marks of hybrids are generally inconstant and evasive, and yet it is of the utmost importance to perspicuous taxonomy that one shall be able to determine hybrids from normal variations. There are certain general evidences of hybridity which the student may apply with very satisfactory results to intermediates of which he suspects a hybrid origin. I have been in the habit of giving seven categories of tests to my students. These have been suggested mostly by a study of known hybrids in domestic plants. The student must be cautioned that the satisfying of any one of these tests is not a proof of hybrid origin, but if the suspected forms answer more or less closely to three or more of them hybridity generally may be inferred with some confidence. These tests are as follows:

A. *Evidences of variation.*

1. Intermediateness of characters between any two species is an evidence of hybrid origin, and this evidence is the greater the more unvariable the suspected parents normally are.

2. Variation or gradation towards one or two related species arouses a very strong suspicion of hybrid origin, and the evi-

dence is the stronger the more numerous the variant individuals are.

3. Monstrous, sportive, and scattering variations are often evidences of hybridity. These evidences are especially significant when they pertain to the inflorescence, or to the essential organs of the flower.

4. Seedlessness, or greatly reduced seed-bearing, is very good evidence of hybridity in cases where related species are fructiferous.

B. *Evidences of distribution.*

5. Intimate association of the suspected forms with species which appear to be their parents is one of the strongest proofs of hybrid origin. It is not essential, as evidence, that the suspected forms grow actually amongst or with the supposed parents, for hybrids often occur at a distance of several rods, and sometimes even a mile or more, from their parents. It often happens, too, that one of the parents will disappear from the neighborhood before the hybrids do. In some instances the two parents are not known in the association because one of them has been overlooked. Some time since I suggested that a certain Carex which a collector sent me was a hybrid, but the collector denied it because one of the supposed parents had never been detected anywhere near his locality. I predicted that it would be found. The next year it turned up close at hand.

6. Rarity of the suspected individuals should be considered to indicate generally hybrid origin if the related species are common.

7. Localness and absence of "range" are most excellent suggestions of hybridity, particularly when the related species have well marked ranges. In other words, hybrids are generally accidental and spasmodic. Examples of my conception may be taken from the native apples and plums. My *Pyrus Soulardi* has a most disjointed distribution, whilst *Pyrus Ioensis* and *P. Malus* have continuous ranges in the same geographical region. My *Prunus hortulana* is similarly dismembered in distribution, whilst

Prunus Americana and *P. angustifolia* have good ranges. These facts first led me to suppose a hybrid origin for *Pyrus Soulardi* and *Prunus hortulana*, a conviction which is reinforced by other evidence, as I expect to publish shortly in detail.

My contention, therefore, is that since we agree that the species is not, as a matter of fact, an entity, we must abandon the conceptions of it which define it upon intrinsic characters; and we must look upon it as a more or less arbitrary division which it is expedient to use in taxonomy and nomenclature.

CORNELL UNIVERSITY.

LABORATORY APPARATUS IN VEGETABLE PHYSIOLOGY.

J. C. ARTHUR.

(WITH PLATES XXIV AND XXV)

IN the development of the laboratory methods in any department of science a need arises for convenient pieces of apparatus of special construction, and also of new adaptations of apparatus already on the market. It takes some time for the need and the supply to become adjusted, and suggestions and information in the earlier stages or days of development are particularly helpful. It is with a desire to contribute to this demand that the following descriptions of apparatus for work in vegetable physiology are given.[1] The several pieces have been devised in the laboratory of Purdue University to supply the requirements of the classes in physiology.

Auxanometer.—The main features of this apparatus were worked out by Miss Katharine E. Golden, while assistant in the laboratory in 1889–93, aided somewhat in the preliminary construction by her brother, Professor Michael J. Golden, of the Mechanical Department of Purdue University. Minor changes in perfecting it have been made as they occurred to those who used it, and especially by Mr. C. W. Meggenhofen, an unusually ingenious and painstaking mechanic, who for two years gave his best efforts to the construction of apparatus for this laboratory, and is still giving some time to it. He is to be credited also with much of the successful detail in other apparatus to be described, especially of the centrifuge.

[1] Some of the apparatus here described in detail was exhibited to the Botanical Club of the A. A. A. S. in 1893 and 1894. It has been in part briefly described also in the Proceedings of Indiana Academy of Science for 1894, not yet generally distributed, and in a descriptive circular and price-list of physiological apparatus, dated January 1, 1895.

The object has been to secure a piece of apparatus that will be simple, easily adjusted, giving so small an amount of tension to the tender part of the plant being studied as to be inappreciable, record with accuracy, and withal comparatively inexpensive.

The apparatus (*pl. XXIV*) stands about 45^{cm} high, and consists of two separate parts. The recording part supports a clock (either a twenty-four hour or eight-day clock) above, with its dial uppermost. To the lower end of the shaft which carries the minute hand is attached a frame supporting two glass rods, each 30^{cm} long. These rods are blackened by holding them over burning camphor gum, and receive transverse marks from a descending needle as they revolve once an hour.

Blackened glass rods in place of a revolving drum were first used on this apparatus, so far as the writer knows. They are very easily handled, and permanent records are readily secured by making blue prints, or the rods themselves can be kept. The principal value of two rods, rather than one, is to act as a control or duplication of the record, although separated by a half-hour interval.

The other part of the apparatus carries the multiplying pulley and needle. The pulley is made of aluminum for sake of lightness, and runs on carefully adjusted parallel bearings. There are one large and two small wheels upon the pulley shaft, permitting a magnification of the amount of growth either eight or fifteen times.

In the earlier machines, shown at the Madison meeting of the American Association for the Advancement of Science in 1893,[2] and illustrated in plate XXIV, the recording needle was a bristle adjusted in an aluminum holder, which slid upon a vertical glass rod, a second glass rod acting as a guide. This was found to be too heavy and clumsy, and has been replaced by a needle of fine brass wire attached to a skeleton carriage of similar wire, running upon two parallel tight wires in place of the glass rods. The needle and carriage together are barely heavy enough to straighten the slender thread used to suspend them, and it is

[2] See BOT. GAZ. **18**: 348. 1893.

usually necessary to put weights of a few milligrams upon the carriage in order to make the machine run uniformly.

Many trials have been made to secure a satisfactory thread for the pulleys. The material found to work best is sewing silk A sufficient length is taken and untwisted, and only a part of one strand used. All attempts to secure a smoother thread by employing wax of some sort have met with indifferent success, and finally have been abandoned. The thread which leads from the plant to the small pulley is carried through a bent glass tube which offers but the slightest possible friction, and obviates the necessity of placing the plant directly underneath.

To adjust the apparatus the thread from the needle carriage is threaded through an opening in the rim of the large pulley wheel and fastened in a slit, the carriage remaining at the bottom of the guides. A thread from the plant is then passed through the glass rod and once around one of the smaller pulley wheels, and after the pulley is turned so that the needle carriage is at the top of the guides, the thread is fastened in a slit at the side of the small wheel. The carriage is now weighted enough to keep the threads barely straight. The recording part is next brought into place, and set so that the point of the needle will make a mark as the blackened rods pass it. To have the recording rods parallel to the path of the needle the apparatus should be set upon a level surface, preferably on a piece of plate glass. As the plant grows the needle descends at a multiplied rate, and leaves the record on the blackened rods.

There are no hanging weights, and no unnecessary pull upon the plant in this machine. The needle carriage and its riders constitute the sole weight for turning the pulley. As the plant grows the thread which leads from it is wound up on the small pulley wheel, and the thread attached to the needle carriage is unwound from the large wheel, permitting the needle to descend.

The small excess of weight permissible above that necessary to overcome the friction of the machine, in order not to influence perceptibly the growth of the organ under observation, makes it imperative that the movable parts of the machine

should be kept in perfect order. It is especially necessary that the pulley bearings be clean and carefully adjusted, and that the guide wires for the needle carriage be kept polished. As the machine is intended to record increments of growth too small to be seen by the unaided eye, it is obvious, moreover, that it should be kept free from tremor or jar. It must, in fact, be treated as a machine of delicate precision in order to secure results of the highest value.

Centrifuge.—This machine (*pl. XXV*) is for the purpose of applying to small plants a force, in connection with or independent of gravitation, that shall induce a strain within the organ of the same physiological nature as that brought about by gravity. A disk of cork 10^{cm} in diameter, to which germinating seeds may be pinned is made to revolve at considerable speed in a moist chamber. The moist chamber consists of a shallow metal pan, into which a deep glass cover is fitted. The bottom of the pan is pierced by two openings, one of which conducts a constant supply of water into the chamber through a rubber tube terminating in a bent glass tube within. The glass tube can be adjusted from without so as to permit the water to fall in drops upon any part of the disk. An opening at the opposite side of the pan takes away the surplus water through a rubber tube.

The revolving disk is turned by a small electric motor, supplied with current from two Edison-Lalande cells of type Q. These batteries are the most satisfactory for small motors yet devised. When setting them up it is best to put the jar into a vessel of water, and let it remain there until the potash has fully dissolved and the excessive temperature abated, to avoid breaking the jar. After the cell is in readiness it requires no further attention until exhausted, when the potash, oil, zincs and carbon must be replaced with new ones. Although this is by far the best motor battery known, yet, like all batteries, it is likely to prove treacherous at times. Where suitable water power, or other more reliable motive power is available, it should be adopted.

When the cork disk is whirled horizontally the centrifugal

force acts in a plane at right angles to that of gravity, and the direction of growth is a resultant of the two forces; when the disk is whirled vertically gravitation is neutralized. In order to secure these positions the first machines made, which were exhibited[3] at the same time as the auxanometer already mentioned, had the moist chambers supported on a metal arc, and held in place by a set screw in the base (*pl. XXV*). But it was found difficult to accurately center the pulley wheel for the different positions, and later machines have been made with the chamber supported on a pinion (*fig. 1*).

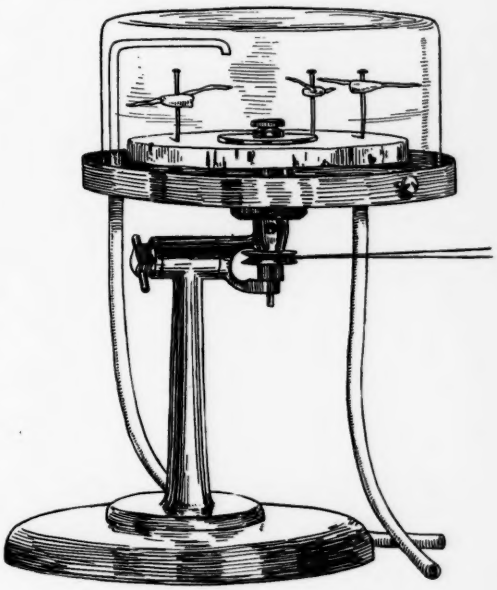


FIG. 1. Centrifuge with iron base.

When the electric motor is used it is mounted, along with the chamber, on a wooden base (*pl. XXV*); when other motive power is employed the chamber is mounted on a heavy iron base (*fig. 1*). To ascertain the speed of the disk a piece of paper is passed over a revolving pencil point for an exact number of seconds. The pencil point is attached eccentrically to the lower end of the spindle carrying the cork disk (*pl. XXV*) and describes a spiral as the paper is moved over it. By counting the number of turns of the spiral, the number of revolutions of the disk for the time is found.

[3] *Ibid.* 344.

Respirometer.—This piece of apparatus (*fig. 2*) is a modification of one employed by Pfeffer,[4] which in turn was adapted from Pettenkofer's apparatus for experiments upon the respiration of animals. It consists of a small chamber in which germinating seeds or other living material is placed, surrounded by water to keep the temperature uniform. A thermometer is plunged in the chamber, and one in the water outside.

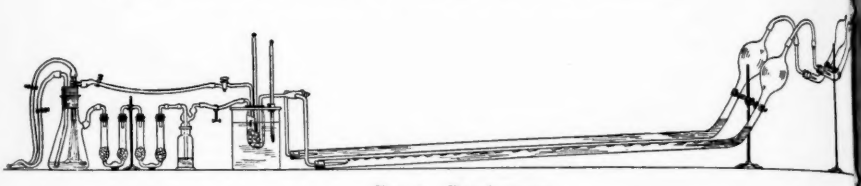


FIG. 2. Respirometer.

Two U-tubes containing potash, and a wash bottle containing barium hydrate solution, are connected in series with the chamber at one end and with an aspirator, or water pump, at the other. At the beginning of an experiment the aspirator draws the air out from the chamber through a direct connection, and forces it through the potash tubes and wash bottle back into the chamber, freeing it of carbon dioxide in the operation. When the chamber is sufficiently free of carbon dioxide, the direct connection with the aspirator is broken, and a stopcock opened which permits the carbon dioxide free air, forced into it by the aspirator, to pass into and traverse a long tube (about a meter) partly filled with a solution of barium hydrate (made by adding 15^{gr} of barium chloride to 5^{l} of distilled water, and after it has largely dissolved adding 105^{gr} of barium hydrate), the gas then passing through a short supplementary tube, also containing barium solution. The bulbs at the distal ends of these tubes are to prevent an overflow, if a sudden increase in pressure should occur. There are two sets of tubes so that continuous observations may be carried on as long as desired. When the test has been in progress for the first period (usually an hour), a three-way cock

[4] Unters. a. d. bot. Inst. zu Tübingen 1: 637.

is turned, directing the stream of gas into the other set of tubes. During this period the first set of tubes is emptied and refilled and made ready for the third period, and so on. The object in having the barium solution in long tubes is to bring the gas well in contact with the solution, so that any carbon dioxide given off by the living material under observation will be taken up and precipitated as barium carbonate. The supplementary tube is to catch any carbon dioxide that may escape precipitation in the the longer tube, usually a very small amount, if any. A definite amount of solution is used in each tube, generally 100^{cc} in the long tube and 20^{cc} in the short one, or enough to fill the straight portions of the tubes. The two are emptied together at the close of the period into a closed vessel, and allowed to stand until the precipitate has fallen to the bottom.

To determine the amount of carbon dioxide that has been absorbed by the barium solution during one period, an integral part of the solution (20^{cc} is a convenient amount), after standing until clear, is titrated. A few drops of rosolic acid are added to the solution to be tested, as an indicator, and a standard acid solution (1.4318^{gm} of dry oxalic acid in 500^{cc} distilled water) is run into it from a graduated burette until exactly neutralized, as shown by the change of color. The same amount of the original barium solution is similarly titrated. The difference in the number of cubic centimeters of the standard solution used for each represents the number of milligrams of carbon dioxide absorbed by the integral part of the barium solution titrated, for one cubic centimeter of the standard acid solution will convert as much barium into an oxalate as one milligram of carbon dioxide will change to a carbonate. To find the total number of milligrams of carbon dioxide given off during the period, multiply the difference just obtained by the factor that represents the ratio of the full amount of barium solution employed in the trial to the amount titrated (six in the case supposed).

This apparatus is found to work with a steady water pressure, but sudden changes in pressure are very detrimental. Its accuracy is also all that is usually required.

The temperature of the respiration chamber can readily be changed by cooling or heating the water surrounding it.

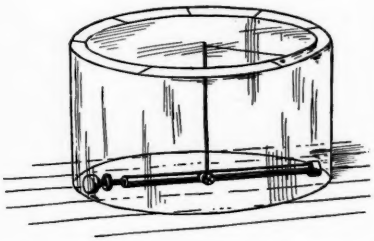


FIG. 3. Awn hygrometer.

Hygrometer. — When the writer was in the laboratory of Francis Darwin at Cambridge in 1888, he was shown a roughly made hygrometer,[5] which has since been used in the Purdue laboratory and modified into the form shown in *fig. 3*. It consists of a small thin glass vessel with a metal bar across the mouth bearing a part of a Stipa (*S. spartea* Trin.) awn. To the free end of the awn is attached an index of fine brass wire. When the air becomes moist, the awn untwists and the index is carried around. To use it two are selected with awns that untwist at the same rate, and fastened to opposite sides of a leaf by means of a mixture composed of wax, oil, and tallow. The leaf may be attached to the plant, or separated from it and kept from wilting by placing the end in water (*fig. 4*). The position of the index on each side of the leaf is marked at the start, and again when one of them has made a complete revolution. The ratio between the number of degrees of the circle traversed by the two indices during the interval is approximately the ratio of transpiration from the two sides of the leaf.

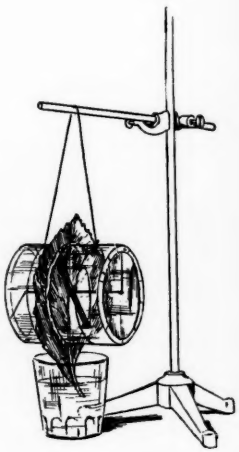


FIG. 4. Hygrometer in use.

[5] Since described and its use fully explained; see Darwin and Acton's Practical Physiology of Plants

The apparatus is not accurate, but makes an interesting demonstration of the general difference in transpiration between the two sides of different kind of leaves.

Slide with binding posts.—The difficulty in attaching wires to tin foil, when wishing to use an electric current under the microscope, has led to the device shown in *fig. 5*. An ordinary microscope slide is provided with a pair of small brass binding posts, each bearing a clip. When in use two wedge shaped pieces of tin foil are placed under the clips with their points near together. The object to be examined is mounted in a drop of water between the points, and covered with a cover slip in the usual manner. It is then placed on the stage of the microcope and the wires from the battery passed into the binding posts.

FIG. 5. Slide with binding posts.

Mercury reservoir.—Mercury is often serviceable and occasionally indispensable in physiological work. Sometimes, as in eudiometric experiments, it must be dry and perfectly clean. The several ways of cleaning mercury are mostly tedious and unsatisfactory, and repeated trials led finally to the adoption of a reservoir that keeps the mercury always dry, clean, and ready for use.

FIG. 6. Mercury reservoir.

The reservoir consists of a thick walled glass separatory funnel, about 15^{cm} in diameter (*fig. 6*). In this the mercury with some mercurous sulfate is placed, together with enough concentrated sulfuric acid to make a quarter-inch layer over the surface. To begin with it is shaken up several times, and in twenty-four hours is ready for use. Mercury drawn from the bottom is pure and dry. After use it is returned to the reservoir where it again becomes usable, without further attention.

The reservoir should be about half full in order to have as much surface of mercury exposed to the action of the acid as possible, and should be kept always stoppered. If mercurous sulfate is not at hand, it can be made by gently heating mercury with concentrated sulfuric acid (1^{cc} mercury to 10^{cc} acid), being careful that there is always an excess of acid. This should be done in a hood.

The reservoir may be placed against the wall by using a ring supported by staples, as shown in the cut.

PURDUE UNIVERSITY,
LAFAYETTE, IND.

POPULAR AMERICAN PLANT-NAMES. IV.

FANNIE D. BERGEN.

[Reprinted by request from plates kindly furnished by the editor of the *Journal of American Folk-lore*.—EDS.

RANUNCULACEÆ.

Aconitum Napellus, L., Adam-and-Eve-in-the-bower, Deering, Me.

Actæa alba, Bigelow, white cohosh, blue cohosh, Paris, Me.

Actæa spicata, L., var. rubra, Ait., black cohosh, Paris, Me.

Actæa, sp., necklace-weed, Me. (W).[1]

Anemone Caroliniana, Walt., mayflower, Burnside, S. Dak.

Anemone Myosurus, var. *minimus* (?), mouse-tail, Cal.

Anemone nemorosa, L., snow-drops, Lynn, Mass.

Anemone patens, var. *Nuttalliana*, Gray, wind-flower, rock-lily, wild crocus, Madison, Wis.
rock-lilies, Brodhead, Wis.
badger, general in Wis.

Anemone Pennsylvanica, L., crowfoot, Burnside, S. Dak.

Anemone Pulsatilla (?), prairie crocus, Mont., Colo., and N. Dak.

Anemone trifolium, spring beauty, Oxford County, Me.

Anemonella thalictroides, Spach., anemone,[2] Sulphur Grove, Ohio.

Aquilegia Canadensis, L., honeysuckle, Madison, Wis.
bells, Sulphur Grove, Ohio.
Jack-in-trousers,[3] Lynn, Mass.
jacket-and-breeches.

Aquilegia truncata, Fisch. & Mey., wild columbine, Cal.

Aquilegia vulgaris, L., blue bells, No. Ohio.

Same, white variety, fairies,[4] Norridgewock, Me.

Caltha palustris, L., coltsfoot, Me.
coltsroot, Sulphur Grove, Ohio.
crowfoot, South Berwick, Me.
capers, Berwick, Me.

Clematis ligusticifolia, Nutt., var. *Californica*, Wats., virgin's bower, wind-flower, Cal.

Clematis Virginiana, L., woodbine, wild hops, Hartford, Oxford County, Me.

Coptis trifolia, Salisb., canker-root, Oxford County, Me.

Delphinium cardinale, Hook., scarlet larkspur, Santa Barbara, Cal.

Delphinium decorum, Fisch. & Mey., blue larkspur, Santa Barbara, Cal.

[1] Names marked thus (W) are taken from Williamson's *History of Maine*.

[2] Sometimes, also, rue-anemone.

[3] Children's name.

[4] Pressed by schoolgirls and carried for a time.

Helleborus viridis, L., Christmas rose, Chris root,[1] Sulphur Grove, Ohio.

Hepatica acutiloba, DC., pass blummies,[2] Alcove, N. Y.
spring beauty, Brodhead, Wis.

Hepatica triloba, Chaix., noble liverwort, Sulphur Grove, Ohio.

Nigella Damascena, L., Jack-in-the-bush, Worcester, Mass.
ragged sailor, Jack-in-the-pulpit, Rutland, Mass.
maid-in-the-mist, Acton, Mass.

Ranunculus acris, L., kingcup, Me. (W).

Ranunculus acris, L., var. *plena*, queens-button, Sulphur Grove, Ohio.
bachelors' buttons, Bethlehem, Pa.

Thalictrum polygamum, Muhl., silver weed, musquash weed, celandine, Oxford County, Me.

CALYCANTHACEÆ.

Calycanthus floridus, L., spice-bush, Middleborough, Mass.
shrub, sweet-scented shrub, Sulphur Grove, Ohio.
sweet Betsies (plantation negroes). Ala.

MAGNOLIACEÆ.

Magnolia glauca, L., sweet bay, Mo.

MENISPERMACEÆ.

Menispermum Canadense, L., sarsaparilla, Parke County, Ind., Sulphur Grove, Ohio.

BERBERIDACEÆ.

Achlys triphylla, DC., May apple, Cal. and Wash.

Berberis aquifolium, Pursh, Oregon grape, Oregon and Wash.
grape-root, No. Utah.

Berberis pinnata, Lag., barberry, Cal. and Oregon.
Oregon grape, Cal.
leña amarilla,[3] Cal.

Berberis vulgaris, L., pipperidge-bush,[4] So. N. H.

Podophyllum peltatum, L., hog-apple,[5] Iowa.

[1] Evidently for Christmas root.
[2] Probably corrupted from *Pasque Blumen*.
[3] Name used by Mexicans and Americans.
[4] A name now almost obsolete.
[5] "Fruit mawkish, eaten by pigs and boys," Gray's *Manual*, earlier editions.

NYMPHÆACEÆ.

Nelumbo lutea, Pers., wonkapin,[1] So. Ind.
Nuphar advena, Ait., kelp, South Berwick, Me.
horse-lily, Hartford, Me.
yellow pond-lily, Millersburg, Ind.

SARRACENIACEÆ.

Sarracenia purpurea, L., foxgloves, Woodstock, Me.
whippoorwill's shoes, meadow-cup, fore-father's pitcher, Me. (W).
whippoorwill's boots, Philadelphia, Pa.
skunk-cabbage, St. Paul, Minn.

PAPAVERACEÆ.

Argemone hispida, chialote (Span.).
thistle-poppy, Santa Barbara, Cal.
Eschscholtzia Californica, Cham.,[2] torosa (Span.).
cups of flame, cups of gold, Cal.
Sanguinaria Canadensis, L., puccoon, Vt.
red puccoon, Sulphur Grove, Ohio.
red root, Me. (W).
sweet slumber, Delaware County, Pa.

FUMARIACEÆ.

Adlumia cirrhosa, Raf., mountain fringe, wood fringe, Paris, Me.
canary vine, Madison, Wis.
Corydalis glauca, Pursh, Roman wormwood, Paris, Me.
Loridales plant, Me. (W).
Dicentra cucullaria, DC., kitten breeches, Sulphur Grove, Ohio.
Indian boys and girls, Madison, Wis.
Dicentra spectabilis, DC., love-lies-bleeding, bleeding hearts, No. Ohio.
ear-drops, Sulphur Grove, Ohio.

CRUCIFERÆ.

Capsella bursa-pastoris, Moench, wind-flower, Fairhaven, Mass.
Dentaria laciniata, Muhl., crow-toes, Sulphur Grove, Ohio.
Erysimum asperum, DC., orange mustard, Cal.
Erysimum officinale, hedge-mustard, Cal.
Hesperis matronalis, L., sweet rocket, Paris, Me.
Lepidium intermedium, Gray, wild tongue-grass, S. W. Mo.

[1] Supposed to be an Indian name.
[2] The California state flower.

Lunaria biennis, L., matrimony vine, Paris, Me.
Raphanus raphanistrum, cadlock (corruption of charlock), Nova Scotia.
Raphanus sativus, L., black mustard, Cal.
Sisymbrium officinale, Scop., California mustard, Rumford, Me.
Thysanocarpus curvipes, Hook., lace-pod, Cal.
Thysanocarpus laciniatus, Nutt., var. *crenatus*, Brewer, fringe-pod, Cal.

CISTACEÆ.

Hudsonia tomentosa, Nutt., poverty-grass, heath, dog's dinner, Wellfleet, Mass.

VIOLACEÆ.

Viola palmata, L., chicken-fighters, Newton, N. C., children.[1]
Viola palmata, var. *cucullata*, Gray, fighting-cocks, New Brunswick.
Johnny jump-up,[2] Sulphur Grove, Ohio.
Viola pedata, L. (and related species), Johnny jump-up,[2] Sulphur Grove, Ohio.
Viola tricolor, L., none-so-pretty, Abington, Mass.

POLYGALACEÆ.

Polygala paucifolia, Willd., bird-on-the-wing, Me.
ladies' slipper, Gardiner, Me.
purple May wing, Me.

CARYOPHYLLACEÆ.

Dianthus Armeria, L., grass-pink, Paris, Me.
Gypsophila paniculata, L. (and other species), mist, babies' breath, E. Mass.
Saponaria officinalis, monthly pink, Greene County, Mo.
sweet Betty, Parke County, Ind.
world's wonder, E. Mass.
lady-by-the-gate, N. C.
Saponaria vaccaria, L., cockle, Blue Earth County, Minn.
Silene acaulis, L., moss pink, Paris, Me.
Silene Armeria, L., mice pink, Hennepin, Ill.
Silene Californica, Durand., Indian pink, Cal.
Silene Cucubalus, Wibel., devil's rattle-box, Stockbridge, Mass.
maiden's tears, Orono, Me.
Silene regia, Sims., wild pink, Greene County, Mo.
Spergula arvensis, L., devil's guts, Paris, Me.
Spergularia, bedsandwort, West.

[1] From a custom with children of locking their spurs to see which head pulls off.
[2] This name is applied to all our native violets.

PORTULACACEÆ.

Portulaca grandiflora, Lindl., rose-moss, Kentucky moss, Sulphur Grove, Ohio.

Portulaca oleracea,[1] L., purslane, Cal.
pursley,[2] Sulphur Grove, Ohio.
pusley,[2] Minn.
pursley or pusley, Parke County, Ind.

Talinum calycinum, Engelm., rock pink, Greene County, Mo.

HYPERICACEÆ.

Hypericum prolificum, L., paint-brush,[3] near Oakdam, Ind.

MALVACEÆ.

Abutilon Avicennæ, Gærtn., butter-print,[4] Iowa, Central Ill.
pie-print,[5] S. W. Mo.
pie marker, Indian hemp, Sulphur Grove, Ohio.

Abutilon, sp., mountain lily, Maine.

Hibiscus Trionum, L., modesty, Sulphur Grove, Ohio.

Lavatera assurgentiflora, Kellogg, tree-mallow, Santa Barbara, and Santa Barbara Islands, Cal.

Malva moschata, L., musk (or mush), Me.

Malva rotundifolia, L., cheeses, Cumberland County, Me.
cheesetts, Oxford County, Me.

Malvastrum coccineum, Gray, moss rose, Burnside, S, D.

Sphæralcea Emoryi, Torr., cimarona (Span.), cheese-weed, Cal.

TILIACEÆ.

Tilia Americana, L., lin tree, Sulphur Grove, Ohio.
white wood, West.

GERANIACEÆ.

Erodium cicutarium, L'Her., alfillarilla or filaree,[6] Berkeley, Cal.
pin clover, Cal.

Erodium moschatum, Willd., alfillarilla or filaree, Berkeley, Cal.
musky filaria, pin clover, Cal.

Geranium incisum, Nutt., crane's bill, Sierra Nevada Mountains, Cal.

[1] Used as food by the Indians.
[2] Evidently corruptions of purslane.
[3] From resemblance of flowers to a small paint-brush.
[4] Alluding to the form of the seed-pods.
[5] Used to stamp pie-crust.
[6] A name used by the Spanish Californians.

Geranium maculatum, L., old maids' night-caps, Madison, Wis.
alum root, alum bloom, crow foot.[1]
Geranium Robertianum, L., mountain geranium, Hancock, N. H.
Impatiens fulva, Nutt., celandine, kicking horses,[2] Paris, Me.
cowslip, wild touch-me-not, Sulphur Grove, Ohio.
Oxalis corniculata, L., yellow sorrel, Cal.
Oxalis corniculata, var. *stricta*, Sav., toad sorrel, Kennebec County, Maine.
sheep's clover, Waverley, Mass.
poison sheep sorrel, Greene County, Mo.
sheep's sorrel, Sulphur Grove, Ohio.
sour grass, Ind.
lady-sour-grass.
Oxalis acetosella, var. *Oregana*, Trelease, redwood sorrel, Cal.

SIMARUBACEÆ.

Ailanthus glandulosus, Desf., devil's walking stick, Sulphur Grove, Ohio.

ILICINEÆ.

Ilex verticillata, Gray, white alder, Oxford County, Me.

RHAMNACEÆ.

Ceanothus Americanus, L., wild pepper, Greene County, Mo.
Ceanothus divaricatus, Nutt., lilac, Santa Barbara County, Cal.
Ceanothus prostratus, Benth., mahala-mats, Cal.
Ceanothus thyrsiflorus, Esch., California lilac, wild lilac, Cal.
Rhamnus alnifolia, L'Her., dwarf alder, West.
Zizyphus Parryi, Torr., lotophagi, lotus tree, San Diego County, Cal.

VITACEÆ.

Ampelopsis quinquefolia, Michx., five-finger.
Vitis cordifolia, Michx., winter grape, Greene County, Mo.

SAPINDACEÆ.

Acer dasycarpum, Ehrh., soft maple, Minn.
white maple, Southwestern Mo.
Acer Pennsylvanicum, L., moosewood, whistlewood, Paris, Me.
Acer rubrum, L., soft maple, Minn.
white maple, Paris, Me.

[1] From shape of root.
[2] From the manner in which the ripe seed-vessel bursts open when touched.

Acer rubrum, L., red maple, hard maple, Southwestern Mo.
Acer saccharinum, Wangenh., sugar tree, Ohio, Ind., and Ill.
Acer spicatum, Lam., swamp maple, Paris, Me.
Cardiospermum Halicacabum, L., puffball, balloon-vine, Sulphur Grove, Ohio.

ANACARDIACEÆ.

Rhus copallina, L., black shumack, Southwestern Mo.
Rhus diversiloba, T. and G., poison oak, yeara, Cal.
Rhus glabra, L., white shumack, Southwestern Mo.
Rhus integrifolia, Benth. and Hook.; and *rhus ovata*, Watson, lemonade and sugar tree, lentisco, San Diego County, Cal.
Rhus toxicodendron, L., poison vine, Ind. and No. Ohio.
poison ivy or poison vine, Sulphur Grove, Ohio.
mercury (marc'ry), picry, Hartford, Me.
Rhus venenata, DC., poison ash, Vt.
Schinus molle, L., pepper tree, Cal.

LEGUMINOSÆ.

Acacia Greggii, Gray, cat's claws, Cal.
Algarobia glandulosa, mesquit, N. Mex. and Ariz.
Amorpha canescens, Nutt., shoe-strings,[1] Minn.; Burnside, S. Dak.
Amorpha fruticosa. L., river locust, Minn.
Amorpha microphylla, Pursh, shoe-string, Burnside, S. Dak.
Apios tuberosa, Moench, pig-potato, West.
Dakota-potato, Minn.
Astragalus caryocarpus, Ker., Buffalo-apple, N. Dak.
Buffalo-bean, N. Dak.; Burnside, S. Dak.
Astragalus Mexicanus, DC., prairie-apple,[2] Southwestern Mo.
Astragalus mollissimus, Torr., rattle-box weed, loco-weed,[3] Cal.
loco-weed,[3] Neb.
Canavalia obtusifolia, DC., wild hop or "'op," Florida Keys.
Crotalaria sagittalis, L., loco-weed, Neb.
Glycyrrhiza lepidota, Nutt., licorice root,[4] Cal.
Gymnocladus Canadensis, Lam., Kentucky coffee bean, Sulphur Grove, Ohio.
Lathyrus palustris, L., wild pea.
Lathyrus splendens, Kellogg, pride of California, Cal.

[1] From the long, tough roots.
[2] Fruit eaten by children.
[3] Pods poisonous to horses; produce a disease in cattle and sheep known as loco.
[4] Roots used by the Indians as medicine.

Leguminosa formosus, sand lupine, Cal.
Lupinus arboreus, Sims., sun dial, tree lupine, Cal.
Lupinus perennis, L., wild pea, Burlington, Vt.
old maids' bonnets, Southampton, Mass., Southold, L. I.
sun dial, Eastern N. Y.
Lupinus, sp., sun dial, monkey faces, Sulphur Grove, Ohio.
Medicago denticulata, Willd., bur-clover, Cal.
Medicago sativa, L., Lucerne, alfalfa, Cal.
Melilotus alba, Lam., honey clover, Greene County, Mo.
Oxytropis Lamberti, Pursh, loco,[1] loco-weed. Neb., Iowa, and Mo.
Parkinsonia Torreyana, Watson, green wood, Ariz.
Petalostemon violaceus, Michx., thimble-weed, St. Joseph, Mo.
Petalostemon violaceus and *P. candidus*, Michx., red and white tassel-flowers, Southwestern Mo.
Prosopis juliflora, DC., honey-mesquit,[2] algarola (Span.), Ariz.
Prosopis pubescens, Benth., curly mesquit, N. Mex.
screw-bean, N. Mex., Ariz., and Cal.
screw-pod mesquit, fornillo,[2] Ariz.
Psoralea esculenta, Pursh, tipsin, Dakota tipsinna,[3] Burnside, S. Dak.
Dakota turnip, Minn.
Schrankia uncinata, Willd., sensitive rose, Burnside, S. Dak.
sensitive brier, shame-faced brier, Southwestern Mo.
Tephrosia Virginiana, Pers., wild pea, Southwestern Mo.
Trifolium arvense, L., pussies, pussy-cats, bottle-grass, Mass.
pussies, pussy-cats, calf-clover, Southold, L. I.
Trifolium incarnatum, L., crimson clover, Cal.
Trifolium megacephalum, Nutt., large-headed clover, Cal.
Trifolium repens, L., honeysuckle, honeysuckle-clover, Oxford County, Me.
Vicia Americana, Muhl., buffalo pea, Burnside, S. Dak.
Vicia cracca, L., Canada pea, Paris, Me.

ROSACEÆ.

Amelanchier Canadensis, T. and G., sugar-pear, Oxford County, Me.
dogwood, boxwood, wild pear, June plum, West.
Amygdalus pumila, flowering almond (flowery ammon), No. Ohio.
Cercocarpus ledifolius, Nutt., mountain mahogany, Cal.
Chamæbatia foliolosa, Benth., tar bush, tar weed, Cal.

[1] From poisonous effects upon grazing animals. See article II. of this series.
[2] Pods used by Arizona Indians as food.
[3] An Indian name.

Cratægus tomentosa, L., red haw, Sulphur Grove, Ohio, Central Ill.
Dalibarda repens, L., robin-run-away, Franklin plant, Oxford County, Me.
Fragaria vesca, L., sow-tit, sheep-nose, Central Vermont.
Geum rivale, L., chocolate, Paris, Me.
maidenhair, Brodhead, Wis.
Geum triflorum, Pursh, prairie smoke, Me.
Nuttallia cerasiformis, T. and G., oso berry, California and Oregon.
Potentilla Canadensis, L., running buttercup, Oxford County, Me.
Potentilla fruticosa, L., hardhack, Stockbridge, Mass.
Potentilla Norvegica, L., barren strawberry, Hartford, Me.; Medford, Mass.
Potentilla, sp., star-flower, Waverly, Mass.
Prunus ilicifolia, oak-leaved cherry, California.
Prunus hortulana, Bailey, hog plum, S. W. Mo.
Prunus nigra, pomegranate, Orono, Me., West.
Prunus Pennsylvanica, L., fire cherry,[1] Franklin County, Me.
Prunus pumila, L., beach plum, Aroostook and Somerset counties, Me.
Pyrus arbutifolia, L., choke-berry, Oxford County, Me.
Rosa cinnamomea, L., primrose, Paris, Me.
Rosa humilis, Marsh (and other species), wild rose, S. W. Mo.
Rosa minutifolia, Parry's Mexican rose, San Diego County, Cal.
Rosa setigera, Michx., rose blush, S. W. Mo.
Rubus cuneifolius, Pursh, sand blackberry, Mo.
Rubus odoratus, L., mulberry, Paris, Me.
Rubus spectabilis, Pursh, salmon-berry, Cal., Oregon, and Wash.
Rubus triflorus, Richards, running raspberry, Oxford County, Me.
pigeon berry, West.
Spiræa tomentosa, L., purple hardhack, West.

SAXIFRAGACEÆ.

Ribes gracile, Michx., Illinois gooseberry, Ky.
Ribes prostratum, L'Her., skunk currant, Oxford and Washington counties, Me.
Saxifraga sarmentosa, L., Otaheite, Paris, Me.
Saxifraga Virginiensis, Michx., everlasting,[2] Lynn, Mass.; sweet Wilson,[3] Abington, Mass.
Saxifraga, sp., Mayflower, Auburndale, Mass.

[1] Always appears on newly burned land.
[2] Children's name.
[3] Named by Mrs. Ward fifty years ago, to please Wilson Ward, who complained that there was a sweet William but no sweet Wilson. Name still extant.

CRASSULACEÆ.

Sedum acre, L., treasure of love, Boston, Mass.
Sedum pulchellum, Michx., rock moss, S. W. Mo.
Sedum telephium, L., Aaron's rod, Paris, Me.
life-of-man, live-forever, Oxford County, Me.

MELASTOMACEÆ.

Rhexia Virginica, L., handsome Harry, Eastern Mass.

ONAGRACEÆ.

Epilobium angustifolium, L., wickup, Paris, Me.
purple rocket, Sally-bloom, York County, N. B.
Siberian flax, Westmoreland County, N. B.
pig weed, Canada.
Gaura, sp., wild honeysuckle, Tex.
Ludwigia palustris, Ell., water purslane, West.
Œnothera biennis, L., scabish, South Berwick, Me.
Zauschneria Californica, Presl., wild fuchsia, Santa Barbara County, Cal.

LOASACEÆ.

Mentzelia ornata, T. and G., Gunebo lily,[1] No. Dak.

PASSIFLORACEÆ.

Passiflora Warei, Nutt., devil's pumpkin, Florida Keys.

CUCURBITACEÆ.

Echinocystis lobata, T. and G., creeper, creeping Jenny, Oxford County, Me.
Sicyos angulatus, L., wild cucumber, Sulphur Grove, Ohio; Central Illinois.

CACTACEÆ.

Cereus giganteus, Engelm., giant cactus, Ariz.
Cereus Greggi, Engelm., three-cornered cactus, Ariz.
Cereus pectinatus, Engelm., rainbow cactus, Ariz.
Echinocactus Wislizeni, Engelm., niggerhead cactus, barrel cactus, fish-hawk cactus, Ariz.
Mamillaria Goodridgii, Scheer., strawberry cactus, So. Cal.
Mamillaria Grahami, Engelm., pin-cushion cactus, Ariz.
Opuntia arborescens, Engelm., tree cactus, Ariz.

[1] Grown in Gunebo Hills.

Opuntia Engelmanni, Salm., prickly-pear cactus, Ariz.
Opuntia frutescens, rat-tail cactus, Ariz.
Opuntia fulgida, Engelm., straw cactus, Ariz.

FICOIDEÆ.

Mollugo verticillata, L., devil's grip,[1] No. Berwick, Me.

UMBELLIFERÆ.

Cicuta maculata, L., snake weed.
Daucus carota, L., bird's nest, Penobscot County, Me.
Daucus pusillus, Michx., rattlesnake-bite cure, *yerba del vibora* (Span.), Cal.
Erigenia bulbosa, Nutt., turkey pea, pepper and salt, Ind.[2]
Eryngium Leavenworthii, T. and G., briery thistle, Waco, Tex.
Hydrocotyle Americana, L., penny post, West.
Osmorhiza longistylis, DC., sweet anise,[3] Sulphur Grove, Ohio.
Osmorhiza brevistylis and *O. longistylis*, DC., sweet jarvil, Hartford, Me.
Peucedanum ambiguum, Nutt., kouse root, bread and biscuit,[4] Cal.

ARALIACEÆ.

Aralia hispida, Vent., pigeon berry, Oxford County, Me.
Aralia nudicaulis, L., sasapril or sasafril, Me.
saxapril and sasafafarilla, Bath, Me.
Aralia racemosa, L., old man's root, spikenard, Oxford County, Me.
Aralia trifolia, Decsne. and Planch., ground nut, Oxford County, Me.

CORNACEÆ.

Cornus alternifolia, L. f., green osier, Paris, Me.
Cornus sericea, L., red willow, Mo.
red brush, Morgan County, Mo.
squaw bush, West.

CAPRIFOLIACEÆ.

Diervilla trifida, Moench, life-of-man, Oak Bay, N. B.
Lonicera ciliata, Muhl., medaddybush, Weld, Me.
Sambucus Canadensis, L., sweet elder, West.
Sambucus pubens, poison elder, Oxford County, Me.

[1] Name given by section-hands along the railroad, because the plant is so hard to eradicate.

[2] Eaten by children and fowls. Called "pepper and salt" from the white petals and dark stamens.

[3] Odor and taste like true sweet anise.

[4] Made into bread by the Indians.

Symphoricarpos vulgaris, Michx., buck bush, S. W. Mo.
Triosteum perfoliatum, L., wild ipecac, West.
Viburnum acerifolium, L., squash-berry, Newfoundland.
Viburnum dentatum, L., withe-wood, So. Berwick, Me.
Viburnum lanlanoides, Michx., moose bush, moose berry, Paris, Me.
dogwood, Bath, Me.
Viburnum lentago, L., tea plant, Madison, Wis.
Viburnum nudum, L., possum berry, Ocean Springs, Miss.

RUBIACEÆ.

Galium (various species), beggar lice, S. W. Mo.
Galium, sp., robin-run-ahead, cleavers, Sulphur Grove, Ohio.
Houstonia, sp., Venus' pride, wild forget-me-not, star violet, Waco, Tex.
Houstonia cærulea, L., forget-me-not, Oxford County, Me.
little washerwomen, Bethlehem, Pa.
blue-eyed grass, Brodhead, Wis.
Mitchella repens, L., two-eyed plum, snake plum, Oxford County, Me.
pigeon berry, Mass.
fox berry, Lynn, Mass.
chicken berry, West.
one berry, Central N. Y.
Morinda Roioc, L., red root, Florida Keys.
Randia clusiæfolia (? *Gardenia clusiæfolia*, Jacq.), seven-year apple, Florida Keys.

VALERIANACEÆ.

Valeriana edulis, Nutt., tobacco root, kooyah, Cal.
Valeriana officinalis, L., hardy heliotrope, summer heliotrope, Sulphur Grove, Ohio.
garden heliotrope, Middleborough, Mass., Northern Ohio.

DIPSACEÆ.

Scabiosa atropurpurea, L., mourning bride, mourning widow, Sulphur Grove, Ohio.
Scabiosa succisa, pin cushions, Sulphur Grove, Ohio.

COMPOSITÆ.

Achillea Millefolium, L., gordolobo, Cal.
Ambrosia Artemisiæfolia, L., hogweed, West.
blackweed, Long Island.
bitter-weed,[1] Sulphur Grove, Ohio, Eastern Pa.

[1] From its effect on the milk when eaten by cows.

Ambrosia trifida, L., horseweed, Sulphur Grove, Ohio.

Anaphalis margaritacea, Benth. and Hook., ladies' tobacco, Hartford, Me.

Antennaria plantaginifolia, Hook., love's test,[1] Ind.
dogs' toes (staminate flowers), Auburndale, Mass.
pussies' toes (pistillate flowers), Auburndale, Mass.
mouse's ear, Oxford County, Me.
poverty weed, Paris, Me.
four toes, mouse-ear, pearly everlasting, Salem, Mass.

Anthemis Cotula, DC., chigger weed,[2] Ind.
balders, (from Hardinge's "With the Wild Flowers").

Arctium Lappa, L., buzzies, Southold, L. I.

Aster cordifolius, L., tongue, So. Berwick, Me.

Aster Novæ-Angliæ, L., Michaelmas daisy, hardy aster, Sulphur Grove, Ohio.

Aster (all forms), frost weed, Paris, Me.
frost flowers, N. H.

Aster (native species), daisies, Sulphur Grove, Ohio.

Aster (cultivated varieties), fall roses, Sulphur Grove, Ohio.

Bidens Beckii, Torr., water marigold, St. Louis County, Mo.

Bidens frondosa, L., old ladies' clothes-pins, Mass.

Bidens frondosa, L., *cernua*, L., and *connata*, Muhl., beggars' ticks, Paris, Me.
pitchforks, Rumford, Me.

Bigelovia venata, Gray, rheumatic plant,[3] *damiana* (Span.), Cal.

Centaurea Cyanus, L., French pink, Sulphur Grove, Ohio, Ala.
ragged robin, Ohio, Baltimore, Md.
barbeau,[4] Louisiana.

Centaurea Melitensis, L., pasture weed, tocolote, Cal.

Chrysopsis villosa, Nutt., rosinwood, No. Dak.

Cichorium Intybus, L., wild bachelors' buttons, Worcester, Mass.
ragged sailors, blue daisies, Southold, L. I.

[1] The test is in this wise: A leaf is taken by the ends, a person of the opposite sex is thought of, and the ends are pulled apart. If the tomentum beneath is drawn out long, the affection is supposed to be proportionate. Sometimes this is varied by naming both ends, when the relative length of the tomentum determines the stronger love.

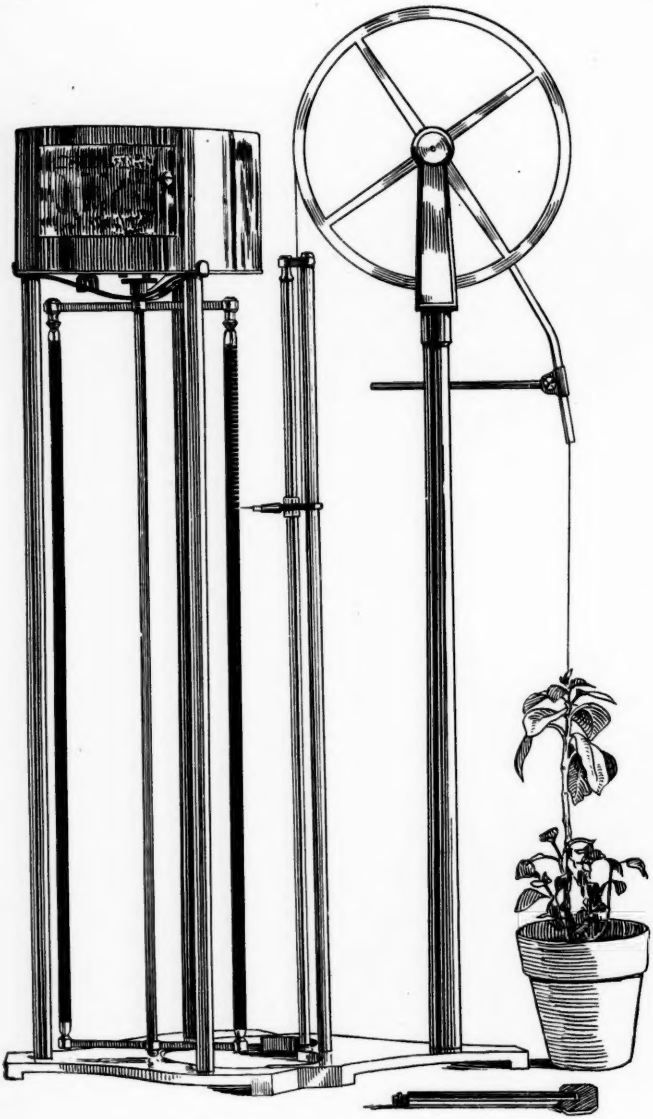
[2] So called because supposed to harbor the "chigger," a troublesome mite which burrows under the skin.

[3] Medicinal, cure for rheumatism.

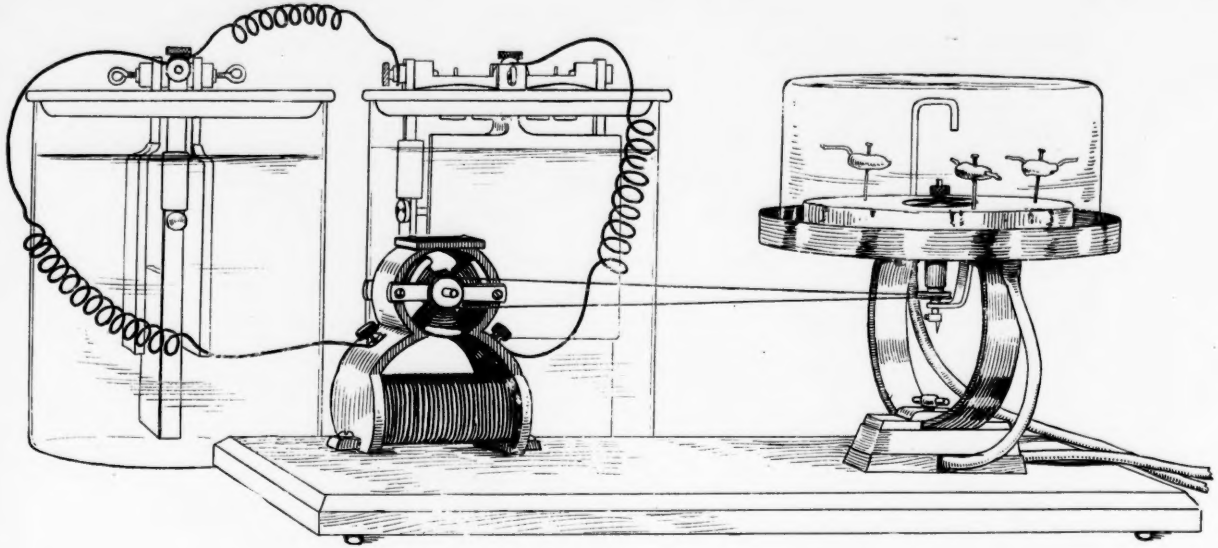
[4] A name common along the Mississippi a generation and more ago, from a M. Barbeau, who brought it from France.

Coreopsis Drummondii, T. and G., lady's breast-pin, Sulphur Grove, Ohio.
Coreopsis tinctoria, Nutt., wild flax, Burnside, So. Dak.
Cotula vulgaris, manyanilla,[1] Cal.
Dysodia chrysanthemoides, Lag., prairie-dog weed, Burnside, So. Dak.
Echinacea angustifolia, DC., and *Lepachys columnaris*, T. and G., respectively comb and brush, Burnside, So. Dak.
Erigeron annuus, Pers., white-top weed, Sulphur Grove, Ohio.
Erigeron Canadensis, L., horse weed, *yerba el pasmore* (Span), Cal.
Erigeron Philadelphicus, L., daisy, Sulphur Grove, Ohio; Burnside, No. Dak.
Erigeron pumilus, Nutt., daisy, Burnside, So. Dak.
Eupatorium ageratoides, L., stevia, Madison, Wis.
Eupatorium perfoliatum, L., throughgrow,[2] Eastern Pa.
Eupatorium purpureum, L., queen of the meadow, Oxford County, Me.
king of the meadow, N. H.
Gnaphalium, sp., ladies' tobacco, Madison, Wis.
Gnaphalium polycephalum, Michx., Indian posy, Southold, L. I.
poverty weed, Paris, Me.
Gnaphalium uliginosum, L., mouse-ear, Paris, Me.
Grindelia robusta, Nutt., gum plant,[3] Cal.
Gutierrezia Euthamiæ, T. and G., broom weed, Waco, Tex.
Helenium puberulum, DC., rosilla, Cal.
Helianthus multiflorus, dahlia sunflower, Sulphur Grove, Ohio.
Hemizonia ramosissima, tar weed, balsamio, Cal.
Hieracium aurantiacum, L., missionary weed,[4] E. Sangerville, Me.
Inula Helenium, L., starwort, West.
Lactuca Canadensis, L., butter weed, wild lettuce, Sulphur Grove, Ohio.
Lactuca leucophæa, Gray, milk weed, Paris, Me.
Layia platyglossa, Gray, tidy tips, Cal.
Matricaria Parthenium, fever-few or feather-few, Sulphur Grove, Ohio.
Othonna crassifolia, cabbage worm,[5] noodle moss, Sulphur Grove, Ohio.
Pectis papposa, Gray, manzanilla coyote,[6] Cal. Desert.
Parophyllum gracile, Benth., sweet-scented herb, *yerba del vernada*, Cal.

[1] Medicinal and sweet-scented.
[2] Evidently from the perfoliate leaves.
[3] Cures poison from ivy.
[4] A recent introduction.
[5] Leaves shaped like a cabbage worm.
[6] So called by the Mexicans.



ARTHUR on PHYSIOLOGICAL APPARATUS.
GOLDEN AUXANOMETER.



ARTHUR on PHYSIOLOGICAL APPARATUS. CENTIFRUGE with MOTOR.

Prenanthes (any species), gall of the earth, Southern Me.
Rudbeckia hirta, L., yellow daisies, Southold, L. I.
black-eyed Susan, Sulphur Grove, Ohio.
brown-eyed Susan, Brockton, Mass.
bull's eyes, ox-eyed daisies, Paris, Me.
English bullseye, York County, Me.
Solidago bicolor, L., silver rod, belly-ache weed, Paris, Me.
Solidago Canadensis, L., yellow weed,[1] Sulphur Grove, Ohio.
Solidago (any species), flower of gold, yellow tops, Cal.
Sonchus oleraceus, L., milk thistle, Cal.
Troximon cuspidatum, Pursh, dandelion, Burnside, So. Dak.
Zanthium Canadense, Mill., cuckle-bur,[2] Sulphur Grove, Ohio.
Zinnia elegans, Jacq., old maid's pink, Sulphur Grove, Ohio.

Fanny D. Bergen.

CAMBRIDGE, MASS.

[1] The species of solidago are rarely called goldenrod by the common people.
[2] Never called cockle-bur.

BRIEFER ARTICLES.

NEW AND NOTEWORTHY WASHINGTON PLANTS.

Cardamine callosicrenata, n. sp. Perfectly glabrous throughout: stems erect, 60 to 70^{cm} high, purplish below, shining above, coarsely striate: leaves all similar and pinnately trifoliate, or some of the radical rarely simple; terminal leaflets orbicular, 3 to 5^{cm} long and nearly as broad, closely crenate or the uppermost lobed, the crenations tipped with a short blunt callous point; lateral leaflets ovate, entire, mostly obtuse, 10 to 15^{mm} long: raceme ample: flowers white: pods 25 to 30^{mm} long, erect on widely spreading pedicels 10^{mm} long: style stout: seeds light brown, about twenty in each pod.

In springy places, Spokane, July 2 and September 27, 1896.

This species has much the aspect of *C. Lyallii* Wats., but is more nearly related to *C. Breweri.*

DRABA AUREOLA Wats., described from Lassen's Peak, California, is found sparingly in volcanic scoria on Mt. Rainier at 10,000 feet altitude. Only two other plants, *Smelowskia calycina* Meyer and *Poa Lettermani* Vasey, occur at higher altitudes on this peak.

ERYSIMUM ARENICOLA Wats. has yellow flowers like others in the same group. It is not rare in its type locality, Mt. Steele, Olympic mountains, and grows either in loose sand or in rock crevices.

ARENARIA PALUDICOLA Rob. (*A. palustris* Wats.). This interesting species, first found in swamps near San Francisco, California, and later at San Bernardino by Parish, has been detected by Mr. J. B. Flett growing in sphagnum swamps near Tacoma. The Washington plants agree well with the specimens distributed by Parish, save that the stems are sparingly branched and the leaves are not at all flaccid. Some of the specimens are peculiar in that the leaves on the uppermost branches are decidedly reduced, but more of the specimens do not exhibit this character. Dr. Behr's note in *Erythea* (Nov. 1896), predicting that this plant will some day be found in Alaska, seems likely to be fulfilled now that it is known to occur in Washington.

STELLARIA OBTUSA Engelm. is not a rare plant in the Blue moun-

tains, at the head of Touchet river. Single specimens of this species form dense cespitose mats often a foot in diameter.

SIDALCEA HENDERSONI Wats. This species was described from a single plant, supposed by its discoverer to be a waif, collected in 1886 at Clatsop beach, Oregon. As long ago as 1887 I collected a single specimen of it on the sea beach near Seattle, and last year found it in abundance in the brackish marshes at the mouth of the Snohomish river near Everett. It is a beautiful species with deep rose flowers nearly an inch in diameter. Apparently it is confined to the immediate proximity of the sea.

Astragalus Palousensis, n. sp. Perennial from a stout woody caudex: stems several, 40 to 60^{cm} high, simple or branched above, striate, sparingly pubescent with short appressed hairs, these white below and blackish above: leaves 8 to 12^{cm} long; leaflets 25 to 31, elliptical or lanceolate, obtuse or even truncate, appressed pubescent beneath, glabrous above, 5 to 20^{mm} (usually about 15^{mm}) long, nearly sessile; petioles sparsely hirsute; stipules deltoid-acuminate: racemes elongate, 5 to 12^{cm} long; flowers 20 to 25, erect on short pedicels, 12^{mm} long; bracts lanceolate, shorter than the calyx: calyx obliquely campanulate, the slender teeth nearly as long as the tube, pubescent with short appressed black hairs: corolla pale yellowish, with or without a black spot on the wings: pod 2^{cm} long, crustaceous, narrowly oblong, tipped with a slender short beak, its surface transversely reticulated and sparsely pubescent with short white hairs; stipe as long as the calyx tube or shorter.

Common on rich loess hillsides about Pullman.

Very closely related to *A. reventus* Gray, and *A. arrectus* Gray. From the latter it differs in the much shorter stipe and beak of the pod; from the former in its more elongate raceme, in the leaves being glabrous above, and in the much shorter and sparser pubescence of the flowers.

RIBES PROSTRATUM L'Her. This species has not hitherto been reported from west of the Rocky mountains. It has been collected by Whited at the head of Twisp river, Cascade mountains, and by the writer near the source of the Duckaboose river, Olympic mountains. The specimens from the latter place are very well developed, some of the leaves being three inches in diameter.

Valeriana Columbiana, n. sp. Stems erect from a rather slender caudex, 20^{cm} high, minutely puberulent especially below: radical leaves

ovate, entire, obtuse at apex, 2^{cm} long, glabrous, their petioles 2 to 3 times as long, narrowly margined, puberulent; cauline two pairs, 3-divided; the basal segments ovate-lanceolate, obtuse, entire; the terminal segment 3-cleft into ovate acutish lobes; petioles as long as the blade or shorter, nearly glabrous: inflorescence loosely cymose, the whitish flowers sessile in the cymules; peduncles puberulent: corolla 15^{mm} long, the tube twice the length of the limb, hairy at base within: bracts linear-subulate, as long as the glabrous fruit: stigma minutely 3-lobed: stamens glabrous.

Wenatchee, June 9, 1896. *Kirk Whited*, no. 140.

BIDENS BECKII Torr. The range of this species is given in the *Synoptical Flora* as "Canada to New Jersey and Missouri." Strangely enough it occurs in Green lake, King county, where it is undoubtedly native, but it has not been detected elsewhere on the Pacific coast. Equally surprising is the occurrence of *Hypericum Canadense majus* Gray on the shores of the same lake. The western limit of the species is given in Gray's Manual as "Lake Superior."

Such a remarkably isolated station for these two plants seems difficult to account for, but I cannot resist the suggestion that it may have been brought about through the agency of migratory water birds.

CAMPANULA AURITA Greene, described from Alaskan specimens, is an abundant plant on the perpendicular cliffs of Mt. Steele, Olympic mountains. The flowers are much deeper blue than those of the common *C. rotundifolia*.

Pentstemon Whitedii, n. sp. (§ EUPENTSTEMON). Stems several from a lignescent base, 2 to 3^{dm} high, puberulent below and glandular pubescent above: radical leaves glabrous or sparingly puberulent, narrowly spatulate-lanceolate, acute, saliently dentate with large obtuse teeth, or rarely entire or nearly so, 4 to 8^{cm} long; cauline leaves about four pairs, ovate-lanceolate, acute, entire or sparingly dentate, clasping at base, the lower puberulent, the upper glandular pubescent especially on the upper side, 3 to 4^{cm} long: thyrsus virgate, interrupted; peduncles and pedicels short: sepals broadly lanceolate, acute, 7 to 8^{mm} long: corolla bilabiate, 15 to 20^{mm} long, "light blue," glandular pubescent without, the lobes puberulent within, throat sparsely bearded: stamens glabrous, the sterile filament secundly bearded for nearly its whole length with golden yellow hairs: entire inflorescence viscidly hirsute: fruit not seen.

Collected in rocky soil near Wenatchee, Kittitas county, July 7, 1896. *Kirk Whited* no. 131.

This species is near *P. ovatus* Dougl. and *P. pruinosus* Dougl., but is easily distinguished by its peculiar radical leaves, viscid pubescence and rather larger flowers.

PINGUICULA VULGARIS L. is apparently not a rare plant in the mountains of Washington. We have it from three stations in the Cascades and it occurs plentifully in the Olympics. All the specimens belong to the form *macroceras*.

EMPETRUM NIGRUM L. forms great mats on wet rocks at altitudes of 7000 to 8500^{ft} on Mt. Rainier. It has not hitherto been reported from south of Alaska.

HIPPURIS MONTANA Ledeb. This Alaskan plant was collected several years since by Macoun in the Selkirk mountains, B. C. It also occurs in abundance in the Olympic mountains, at 5000^{ft} altitude, and on Mt. Rainier at from 4000 to 5000^{ft} altitude. Its occurrence on this peak at so low an altitude indicates that it extends much farther south in the Cascade range. In all probability it has been overlooked or mistaken for a moss, as it resembles in no small degree a sterile Polytrichum. — C. V. PIPER, *Agricultural College, Pullman, Wash.*

ANOTHER "COMPASS" PLANT.

SEVERAL years ago I noticed the fact that *Wyethia amplexicaulis* was a "compass" plant, and its peculiarities are marked enough to deserve description. The radical leaves of this plant are from twelve to eighteen inches in length, lance-oblong, perfectly glabrous and minutely resiniferous. Usually they number from six to ten, and if the plant is shaded are widely spreading. However, when the plant is growing in open situations the whole blade may be perfectly erect and turned so as to face east and west. More commonly only the terminal portion of the blade is affected, which in this case is sharply twisted to bring it into position.

The stem of Wyethia is from one to two feet high and bears from three to five leaves which are shorter and broader than the radical, and sessile by a clasping base. Owing to their more favorable position, these cauline leaves exhibit their peculiarity well. They are always rigidly erect and so twisted at base that any leaf usually faces the leaf immediately above it and the one immediately below it; in other

words, the leaves face alternately east and west. On open gravelly prairies this is especially noticeable, as the plants are so much more conspicuous when seen from the east or west than they are when seen from the north or south.

Microscopic examination of the leaf of Wyethia shows the palisade tissue equally developed on each side. The average of a number of counts indicates about forty stomata to the square millimeter on the upper surface of the leaf and about fifty-five on the under surface.

In comparison with the introduced *Lactuca Scariola* Wyethia proves to be a decidedly better "compass."— C. V. PIPER, *Agricultural College, Pullman, Wash.*

EDITORIALS.

Botany for Secondary Schools

IT HAS SEEMED to the GAZETTE that botanists should interest themselves in the various movements among teachers for the proper teaching of science in secondary schools. The problem as to the kind of botany to be taught is not yet settled, and we fear that the advice obtained from the universities has not shown a full knowledge of the necessities and the conditions. Botanists combined to scout at the old "analysis" as an utterly inadequate presentation of botany even as a young student should see it, and they did well. Such work is not merely partial, but misleading; an injustice to both pupil and subject. But has the proposed substitute proved any more beneficent in its results? Has the swing of the pendulum from analysis to morphology done for the schools what was hoped? The university laboratories were ready enough to show how morphology should be taught, to point out the types useful for study, to name the appliances needed, and even to write guides and text-books so that no one need go astray. But what has been the result of it all? The writer is free to acknowledge, from a careful inspection of much of the best work done in the best equipped secondary school laboratories, that the advice was a blunder. The reason is not far to seek. It does not lie in lack of preparation on the part of the teacher, for universities are annually sending into the schools teachers who are trained to do just this kind of work. It lies in the age of the pupils and the structure of the schools. Such work has not resulted in a clear elementary conception of botany, but in a clear conception of nothing. The pupil is taken away from any possible experience of his own in reference to plants, and is introduced to structures which he can fit to nothing. The time limits for laboratory work are so short even in the most liberal schedules that his observations cannot be related properly in his own mind, and hence become perfunctory and meaningless. He is hurried rapidly from type to type, obtains glimpses of things through the microscope, and if the teacher is university bred and young his instruction will take such a philosophical turn that the pupil is hopelessly befogged. It has

been forced upon us, against our will and preaching and former best judgment, that botanists must recommend something else.

WE BELIEVE that the botanical field for the secondary school is that of ecology, and that modern morphology should be left to the colleges and universities, where maturity, and time, and apparatus, and teachers, are all adequate. The preparatory student needs to come in contact with plants in their general relations, to learn to look upon them intelligently in the mass, before he begins the continuous study of minute structures. The introduction of pure morphology has removed him from contact with plants as living things inhabiting the world, a contact which the old "analysis" gave in a sentimental rather than scientific way. He can be introduced to plants as a whole, not to "flowers" merely; he can study their habits of life, their adaptations to various conditions, the societies which they form. Certain intimate structures must be studied to make relations and adaptations significant, and so the microscope cannot be banished, but it can be made an incidental piece of apparatus, rather than the necessary aperture through which every glimpse of botany must be obtained. With ecology as the main purpose, and a certain amount of physiology and morphology as necessary adjuncts, such an impression of plants in general can be made that the more formal university courses will be much more significant than they are. In our judgment such work in the secondary schools not only will show better results in the schools themselves, but will send better prepared students into our university laboratories.

The American Tropical Laboratory

IT IS A CAUSE for congratulation that American botanists seem to be much interested in the tropical laboratory suggested in an editorial of the November GAZETTE. An expression of interest, however, to be effective, must be followed by a definite plan vigorously prosecuted. In the present number we publish an open letter from Professor MacDougal, whose research work is peculiarly in need of development in a tropical environment. As Mr. MacDougal has already planned a visit to the American tropics, the GAZETTE proposes that he be appointed chairman of a committee on inspection, associating with himself such other botanists as he may be able to secure. It should be the work of such a committee not merely to examine suitable locations, but also to

learn the conditions under which a grant from the government could be obtained, the conditions and cost of living, in short, all those facts, botanical, financial, governmental, and hygienic, which must enter into any plan of action. It is further suggested that a report be made by this committee next summer to the various botanical organizations which meet in convention with the American Association. In the meantime the GAZETTE would be glad to hear from those institutions and individuals who are willing to cooperate in the establishment of such a laboratory.

OPEN LETTERS.

A TROPICAL LABORATORY.

To the Editors of the Botanical Gazette:—The recent editorial in the GAZETTE concerning the establishment of a laboratory in the tropics, in the opinion of the writer, calls attention both to the most pressing needs of American botany, and to the most important means of advancement and preservation of the integrity of the science in general. Previously to the appearance of your editorial I had sent to press in the *Popular Science Monthly* an article in which I had touched upon this point. Partial notes upon several problems, the solution of which may only be accomplished in the tropics, have accumulated in my laboratory, and an expedition to the West Indies in the summer of 1897 has been planned for the purpose of beginning work and selecting a suitable locality for its annual continuance. Necessarily temporary quarters would have been secured each year. I would welcome the establishment of a permanent tropical laboratory open to students during the entire year and free from the inconvenience of temporary facilities, to say nothing of the manifold advantages afforded by such an institution in the matter of equipment and accessibility of material.

I would gladly put aside plans already formed and cooperate in any effort leading to the organization and selection of a locality for a laboratory of this character, or aid in any movement leading to its establishment.—D. T. MACDOUGAL, *State University of Minnesota.*

THE BUITENZORG GARDENS.

To the Editors of the Botanical Gazette:—The following excerpts from a letter recently received from Mr. David G. Fairchild, who is making some special studies at the Botanic Gardens, Buitenzorg, Java, may be of interest to the readers of the GAZETTE:

"Dr. Treub, the director of the gardens, is taking steps to establish an international affair here, similar to that at Naples, except that the whole expense of running such a place will be borne by the Dutch government. I am anxious to see a table here and hope when I return to get assistance in bringing this about. What is needed is a yearly or bi-yearly grant which will enable a botanist or zoologist to spend six or eight months at the gardens. Tickets are now sold from Hong Kong to New York for forty-five pounds

sterling, and it is very probable that if proper steps were taken round trip fares could be obtained for seventy-five pounds. It will require another hundred pounds to support a man here for six or eight months. Board, room, washing, and servant cost about $45 per month. It must of course be remembered that the table is free, providing we get a grant which will enable a man to come here. There is no question as to the wealth of material, and I trust that sufficient interest can be aroused to give Americans a chance to utilize it. Various German societies have already acted in the matter."

"As for climate and its effects on one's health, I need only say that I work with the microscope from 6:30 A.M. to 8:30 A.M., and from from 9:30 A.M. until 1:30 P.M. After 8 P.M. attempts at work bring on sleeplessness, which must be avoided. . . . . I find it easy to get everything needed here in the way of apparatus, literature, etc. There are chemical, entomological, and botanical laboratories within easy reach, and a fine library, where most of the important botanical journals are kept on file. Everything is conducive to good work; in fact in this respect the place is the best I have so far seen."—B. T. GALLOWAY, *Washington, D. C.*

ON THE USE OF THE TERM "FROND" AS APPLIED TO FERNS.

To the Editors of the Botanical Gazette:—One of the greatest annoyances of my early experience with fern literature was caused by the use of terms in a double sense. This was especially objectionable and confusing in the use of the term *frond* which was applied indiscriminately to the leafy portion and footstalk combined, and to the leafy part alone, so that it was not always possible to tell just which was meant by the use of the term.

It seemed to me that botanical terms should have but one definite meaning and be used in that sense alone.

Accordingly when in 1881 I prepared a rough plan for a text-book and synopsis of North American ferns I adopted the method of using terms in a single sense only, and I have adhered to that method in my own practice ever since.

Recently I have taken up my manuscript again with the hope of being able to get it ready for publication, but as I may not be able to do so and as the adoption of the word *leaves* for *fronds* in the same objectionable double sense by the new flora in its treatment of the ferns is only another method of retaining the same confusion, I offer the following extract from my manuscript as an expression of my views:

"A frond in its highest state of development consists of two parts, a leaf-like expansion that is the equivalent of the blade of a leaf, and a footstalk that is the equivalent of the petiole of a leaf. The expanded leafy portion is

always the most conspicuous part, just as the blade of a leaf is its most prominent feature, and it is very generally regarded as the frond itself. The term frond, therefore, is generally used in that sense as well as in its own. But the objection to this is that in practice it does not express clearly enough the exact meaning intended. This is especially true when the term frond is used in descriptions of proportion, as for example, when it is said that a frond is six inches tall, meaning thereby the leafy portion only, and the length of the stalk is given separately at four inches, as if it was distinct from the frond, whereas the stalk is an essential part of the frond itself, which would be described better by saying that it was ten inches tall, thus including its footstalk and giving its true length. Then if the proportion of each part was wanted it could be given separately under special terms, and the sum of both would conform to the total of the whole."

"We may thus avoid all the ambiguity arising from the use of terms in a double sense by restricting the term frond to its legitimate definition, and employing special terms for the different parts of the frond itself. This method will prevail throughout the present work, and whenever the term frond is used it is to be understood as meaning the entire leaf, with or without a stalk. Whenever a stalk is present its presence will be recognized by the special term *stipe*, the equivalent of footstalk (Latin *stipes*, plural *stipites*), and the leafy portion will be called the *lamina* (plural *laminæ*). Thus we shall have definitely fixed terms, with clearly defined limitations, no one of which can trespass upon the province of the other" (ex Mss. ined. 1881).—GEORGE E. DAVENPORT, *Medford, Mass.*

DUPLICATION OF CONTRIBUTIONS.

To the Editors of the Botanical Gazette:—That European botanists may occasionally overlook contributions from laboratories on this side of the Atlantic if brought out in ephemeral or obscure journals is naturally to be expected. The American botanist, in turn, may be pardoned for similar mistakes, if not of too frequent occurrence, in regard to publications on the other side. The neglect of the literature bearing upon a distinctively American plant, to be found in the oldest and most widely known botanical journal in the country, is a fault not so easily condoned, however.

Dr. Homer Bowers published in the BOTANICAL GAZETTE[1] a thorough and accurate account of the morphology and life history of *Hydrastis Canadensis*, obtained by ten years of work upon the plant, under cultivation, and in its habitat in central Indiana.

Dr. Julius Pohl has recently duplicated this contribution in a manner which admits of no extenuation.[2] He worked upon a stock of material con-

[1] BOT. GAZ. **16**:73. 1891.

[2] Botanische Mitteilung über Hydrastis Canadensis. Bibliotheca Botanica 29, 1894.

sisting of thirty plants grown from rhizomes taken from the soil during the previous year, four two-year-old seedlings and two seedlings (presumably in the first year of growth) and a few ill developed seeds, according to his own account, in the Botanic Institute at Marburg, May–June 1893. His article exhibits no reference to Dr. Bowers' splendid work, which he has repeated, and not always in an accurate manner, since his results are a most striking example of the faulty conclusions which may be obtained from material under abnormal conditions. Dr. Pohl deals also with the minute anatomy of the plant, and the three pages devoted to this subject may be considered as the only original portion of his paper. The sections devoted to the systematic position of the species, its drug extracts and their adulterations, may be compiled from the common text-books and technical dictionaries, and are furthermore notably incomplete.

It is, of course, safe to assume that Dr. Pohl was unaware of Bowers' work. His ignorance may be directly due to the fact that "the file of the BOTANICAL GAZETTE is not to be found in the Marburg Institute," but it is a logical outcome of the assumption that the boundaries of botanical science are identical with those of Germany. Our brethren across the water would do well to rid themselves of this erroneous idea, once more nearly true than at present. Their repeated disregard of outside literature will certainly do much to lessen the prestige of the German Institute.

The above criticisms apply with peculiar force to the editors of the *Bibliotheca Botanica*. This publication consists of a series of "Originalabhandlungen," and the long interval between issues would certainly allow the verification of the eligibility of any manuscript. A regard for the ethics of the science, and simple justice to their subscribers, demands no less.— D. T. MACDOUGAL, *State University of Minnesota.*

CURRENT LITERATURE.

BOOK REVIEWS.

The survival of the unlike.

THE making of books is easy to Professor Bailey, if one may judge from the number and rapidity with which they come from his pen. Besides new editions of the *Nursery book* and the *Horticulturist's rule-book*, the ink is hardly dry upon *Plant breeding* until the *Survival of the unlike* appears. The *Evolution of our native fruits* is said to be in press, and we are promised shortly a book on pruning, one on the apple, and a school text-book of botany! Professor Bailey is a living disproof of the doctrine that overproductiveness is at the expense of the quality of fruit.

The present book[1] has involved recently only the labor of revision, since it is a collection of essays which have been read from time to time in the last six years before various scientific bodies. All of them have been published before, but are scattered from Dan to Beersheba in all sorts of reports, proceedings, and journals. Were there nothing but the question of convenience involved it were well to bring them together.

But the botanist and horticulturist will find both interest and instruction in these essays. To the botanist they are particularly suggestive, for his studies too often cease at the garden fence. As a study in variation they bring to his attention many facts new to him, of which he would do well to take heed lest he teach theories which facts are against. Professor Bailey's thesis—it may almost be called—is this: "Heredity is an acquired force; normally and originally unlike produces unlike." He "denies the common assumption that organic matter was originally endowed with the power of reproducing all its corporeal attributes, or that, in the constitution of things, like produces like." Now this view is at first somewhat startling, but botanists know already many facts which support it, and Professor Bailey introduces many facts in the course of the essays to strengthen it.

In the second and third essays, respectively "Neo-Lamarckism and neo-Darwinism" and "The philosophy of bud variation," the author shows clearly the untenability of Weismann's germ-plasm theory as concerns plants. The latter essay is particularly striking in setting forth the idea that bud variation is not rare and exceptional, but common; that it is of great

[1] BAILEY, L. H.—The survival of the unlike: a collection of evolution essays suggested by the study of domestic plants. 12mo. pp. 515. figs. 21. New York: The Macmillan Co. 1896. $2.00.

importance in the production of new garden varieties (no less than 300 of such origin being grown at present in this country); and that it is of the same fundamental nature as seed variation. The key to this is to be found in the sentence, "The truth is . . . . that every branch or phyton is a bud variety, differing in greater or lesser degree from all other phytons on the same plant."

But the book must be read to be appreciated. There are too many fruitful ideas to permit discussion of them in detail. We have further space only to quarrel with two.

We doubt whether the idea of the phyton, of which the author makes a point, is of any real value, morphologically or physiologically. Will not rather the idea of the shoot, whether primary, secondary, or of higher order, answer Professor Bailey's purpose better? That shoots as a whole, and the phytons taken from different shoots, are unlike every one knows. But do noteworthy differences exist between the successive internodes of a shoot? It is not unlikely that our author would assent to this change, for we find him saying on p. 250, "We are bound to look upon every branch as in some sense a distinct individual, since it is unlike every other branch." Yet recently we found the conception of the phyton about to be introduced into an elementary book on botany for horticultural students "because Professor Bailey uses it in his writings." Wherefore the query.

There is one essay which we think the author would have done a service either by omitting or by radically altering, the one on sex in fruits. Professor Bailey, in an earlier part of this volume, reprints his note from *Science* on the "Untechnical terminology of the sex relation in plants," and reasserts his conviction that the ascription of sex-relations to the sporophyte by the use of sex terms is "perfectly proper," and often necessary for perspicuity. Of course he is entitled to this opinion, in spite of the botanists who hold it to be erroneous. But can he justify the use of sex terms correctly and (as he himself acknowledges) incorrectly in the same essay? And can he permit himself to reason regarding the evolution of sex from premises that are not only false but that are incomparable, as he does on pp. 347–9? Can such reasoning lead to "a perspicuous treatment of the subject"? We feel sure that when Professor Bailey gives this matter the consideration it deserves he will be as unwilling to have his philosophy shut in by the garden fence as he is desirous that botanists should not have theirs stop at it.—C. R. B.

MINOR NOTICES.

WE HAVE just received separates of two papers from the Transactions of the Kansas Academy of Science for 1893–4, one on the Erysipheæ of Riley county, Kansas, by Lora L. Waters, and the other a list of the grasses of Kansas, by Professor A. S. Hitchcock.

MR. C. J. ELMORE reviews[1] the several systems of classification of the diatoms, favoring Petit's as approaching "most nearly to a natural one, because based on characters having a physiological significance," viz., on the structure of the endochrome and the mode of forming auxospores. In higher plants these are unstable characters; are they not likely to be so also in the diatoms?

FOR SOME TIME before his death, Professor D. C. Eaton had been preparing to issue a set of *Sphagna* in collaboration with Mr. Edwin Faxon. That work has now been completed by Mr. Faxon, and a set of 172 specimens, representing 39 species, their varieties and forms, has been issued by Mr. Geo. F. Eaton with the title Sphagna Boreali-Americana Exsiccata. Most of the determinations are by Warnstorf, and no pains have been spared to make the set first-class in every particular. Those who already know the beauty of specimens prepared by Mr. Faxon need not be assured that these are fine and abundant. For the credit of American bryology it is only just to say that no previous issue of moss exsiccati anywhere to our knowledge surpasses this one in the abundance and beauty of the specimens or in careful labeling. Sixty sets will be issued at $15 per set.—C. R. B.

IN HIS ADDRESS upon "grasses," before the Massachusetts Horticultural Society last March, Mr. F. Lamson-Scribner gave a brief account of the uses, form, structure, and distribution of grasses, and then discussed the economic grasses of Massachusetts, concluding with a short statement of the work of the division of agrostology.

As a part of this work we note the recent issue of a bulletin (No. 3) upon useful and ornamental grasses of all countries. In the introduction a number of the most important economic grasses are classified according to their uses, while the body of the bulletin enumerates about 375 species, illustrated by eighty-nine figures, with a short account of their qualities, value, and culture. The compilation is a very useful one.

NOTES FOR STUDENTS.

A LIST of parasitic fungi, occurring in the state of Mississippi, supplementary to the one printed in May 1895 (Miss. bulletin no. 34), has been issued from the Mississippi Experiment Station (Bull. no. 38) by S. M. Tracy and F. S. Earle. It adds 85 species to the former list, of which 21 are new to science. The descriptions of the new species have also been published in the *Bulletin of Torrey Botanical Club* for May of this year. *Cercospora flexuosa* Tracy & Earle, and *C. Diospyri ferruginea* Atkinson, are reduced to synonyms of *C. Diospyri* Thümen, the three names having been applied to different stages of growth of the same fungus.—J. C. A.

[1] American Naturalist **30**: 529–536. 1896.

UNDER THE TITLE, "The suction-force of transpiring branches," S. H. Vines gives[2] a review of earlier experiments to show the means by which a current of water is maintained between the roots and the leaves of plants, and the results of some recent experiments to determine the suction-force of the leaf, which force has been suggested as the probable cause of sap elevation.—S. C. S.

SEPARATES have been distributed by Professor M. C. Potter,[3] of Durham College, England, detailing the development and nature of the conidial stage of *Botrytis cinerea*. It appears to be a saprophyte, which grows less readily as a parasite, and is the initial cause of the rotting of stored turnips, etc. The conidia germinate readily in moist air, and infection takes place best through wounds or injury due to freezing. The fungus is more aggressive as a parasite after growing for a time saprophytically.—J. C. A.

KRAUS has studied at Buitenzorg[4] the heat produced in flowers of cycads, palms, and arums. His measurements in the spadices of *Ceratozamia longifolia* and *Macrozamia Mackenzi* showed a daily period repeated for several days, with a mid-afternoon maximum, the maximum temperature excess being 11.7° C. Among the palms, *Bactris speciosa* showed a rise of temperature for several days, continuing through the night also. In the Araceæ a daily period with an evening maximum was observed, coincident with which was the intensity of odor.—C. R. B.

NESTLER has communicated to the Royal Academy of Sciences in Vienna the results of researches upon the excretion of liquid water by leaves.[5] He finds that the special tissue often developed between the end of the tracheids and the water pore does not act as a secreting tissue, as has long been taught, but that the extrusion is due wholly to filtration under pressure. Many experiments show this; the following one may be cited as illustrative. If the excretion of water from young grass blades is checked by choking the water clefts or by killing the tips with hot water, the excretion appears in different places along the margin, probably through air pores.—C. R. B.

ITEMS OF TAXONOMIC INTEREST are as follows: F. V. Coville has published[6] a new Ribes, *R. erythrocarpum*, from Crater Lake, Oregon, a region of the southern Cascades that seems never to have been explored botanically.

[2] Ann. Bot. **10**: 429–444. 1896.

[3] Rottenness of turnips and swedes in store. Reprinted from Jour. Bd. Agric. **3**: — [1–14]. 4 plates.

[4] Physiologisches aus dem Tropen. III. Ueber Blütenwärme bei Cycadeen, Palmen, und Araceen, Annales du Jard. bot. de Buitenzorg **13**[2]: 217–275. *pl. 3*. 1896. Cf. Bot. Cent. **68**: 119. 1896.

[5] Œsterr. bot. Zeits. **46**: 371. 1896.

[6] Proc. Biol. Soc. Washington **10**: 131–132. 1896.

The same author has published[7] also a new rush from the Rocky mountain region, *Juncus confusus*, which has heretofore been confounded with *J. tenuis congestus* Engelm. In the same connection a synopsis of *J. tenuis* and its allies, seven species in all, is given. Professor E. L. Greene's last fascicle of "new or noteworthy species"[8] contains descriptions of new species in the following genera: Cratægus, Mentzelia (2 sp.), Coleosanthus, Solidago (2 sp.), Chrysopsis, Grindelia (3 sp.), Aster, Arnica (4 sp.), and Senecio (4 sp.). Among the numerous new species which Mr. Hemsley has described[9] from an interesting collection received from central Tibet is a new genus of grasses which he has named *Littledalea*.—J. M. C.

DR. W. ARNOLDI has obtained some interesting results from his study of Isoetes and Selaginella.[10] The species used were *I. Malinverniana* and *S. cuspidata*, and their association under the title indicates the author's conclusion that Isoetes is to be regarded as a heterosporous lycopod. In the formation of the prothallium of Isoetes the macrospore nucleus passes to the apex of the spore and divides, the daughter nuclei again dividing. At this time the arrangement and staining of the striations of protoplasm about the nuclei indicate that cell walls are about to be formed. The spore wall becomes double and walls are formed about the nuclei, usually leaving the nucleus unenclosed on the side toward the center of the macrospore. The unenclosed nucleus divides, and the daughter nucleus nearest the periphery of the macrospore becomes enclosed by a wall. The free nucleus continues to divide in the same manner, one of the resulting nuclei constantly passing outward and toward the center of the macrospore, until all are enclosed. The enclosed nuclei near the apex of the spore continue dividing, and become separated by new walls. New cells are formed more rapidly along the periphery of the macrospore, but are more tardily extended toward the center. Cell formation is not usually completed in the basal and central parts of the macrospore when archegonia are fully formed at the apex.

The process in Selaginella is so similar to that in Isoetes that the same figures might easily serve to illustrate both. The nuclei divide and become enclosed in the same way, the prothallia are in about the same stage of development when the archegonia appear, and even the comparative size of cells in homologous portions of the prothallia is the same. In Selaginella no diaphragm appears separating the prothallium into vegetative and reproductive parts. In Isoetes the archegonia do not become green.

It becomes evident that the processes here observed are very similar to endosperm formation in the spermatophytes. Much more evidence upon

[7] *Ibid.* 127–130.

[8] Pittonia **3**: 99–106. 1896.

[9] Kew Bulletin **119**: 207–215. 1896.

[10] Die Entwickelung des weiblichen Vorkeimes bei den heterosporen Lycopodiaceen. Bot. Zeit. **9**: 159–168. 1896.

this point may be obtained when the early stages in the endosperm formation of gymnosperms has been more thoroughly worked out. It is to be regretted that Dr. Arnoldi did not extend his work into the embryogeny of the sporophyte. Additional evidence upon the suspensor formation in this group may help to answer the question concerning the supposed relationship of lycopods and gymnosperms.—O. W. C.

MR. J. H. HART discusses briefly[11] the so-called "irritability" of the flowers of *Catasetum tridentatum* Hook., of which Darwin gives an account in his *Fertilization of Orchids*. In opposition to Darwin's observations he says:

"The ejection of the pollinia can be caused by other means than the irritation of the antennæ by touch . . . . A concussion of the flower, the removal of the anther cap, and pressure exerted on almost any part of the column, and especially any irritation on the margins of the stigmatic pit will effect this readily if the flower is at a favorable stage of maturity.

" . . . . the expulsion of the pollen does not depend upon any special irritability, but upon *mechanical action alone*."

"The antennæ are seen to be merely a prolongation of . . . . the edges of the stigmatic pit . . . . A part of this curl . . . . holds the margin of the caudicle . . . . The antennæ at . . . . anthesis become turgid, stiff, and non-elastic. In this state they furnish levers which are amply sufficient to cause a disturbance of the grip they hold upon the margin of the caudicle."

The question needs further study. It is one which can only be satisfactorily examined in a tropical laboratory.—C. R. B.

A BRIEF SUMMARY of MacDougal's work on the mechanism of curvature of tendrils[12] is as follows: Those tendrils which are irritable to contact are of such great difference in morphological derivation, anatomy, and degree of irritability, that it is unsafe to assume their mechanism to be identical. The curvature of a tendril about a support as a direct reaction to irritation, and the coiling of a free portion, are entirely distinct and largely independent processes.

Curvature in the tendrils of Passifloreæ is due to the contraction of the tissues of the concave side, which theory is not in harmony with that of De Vries, viz., that increased osmotic activity of the convex side results in an accelerated growth extension of the tissues of the same side.

The structure of the protoplasm of the convex and concave sides is quite different, that of the concave side being more richly granular, and more nearly filling the cell cavity. The density of the protoplasm of the concave

[11] Bull. Misc. Inform. Roy. Bot. Gard. of Trinidad **2**: 225. 1896.

[12] Annals of Botany **10**: 373–402. 1896.

side increases from the base toward the tip, apparently corresponding with the degree of irritability to contact.

During curvature the parenchymatous cells of the concave side decrease in size from 20 to 40 per cent. of their original volume, and become irregularly globoid or ovoid; which is to be explained by an increase in the permeability of their protoplasts, with a consequent extrusion of water into the intercellular spaces, and a release of their stretching tension exerted upon their walls, the elastic contraction of which causes the resultant curvature.—W. R. M.

DR. EMIL KNOBLAUCH. the German translator of Warming's *Geographical Botany*, has published from Tübingen a paper upon the "Ecological anatomy of the woody plants of the South African evergreen bush-region." A review by Dr. E. Roth[13] gives a brief summary of the results. The rainy winters and dry summers of the Cape Colony region result in a peculiar vegetation, in which dwarf shrubs dominate, both in species and individuals, trees being almost wholly absent. The woody plants are first treated, as, on account of their long duration, they show best the influence of external conditions upon vegetation, notably their adaptation to withstand drought. The anatomy of the leaves is especially considered, as they show most clearly these influences. The many evidences of a direct adaptation of the South African woody plants are enumerated as follows: (1) lignification; (2) evergreen habit; (3) dwarf growths, associated with thick branching, small branches, very short internodes and small leaves; (4) leaves more or less densely aggregated; (5) leaves more or less erect on the branches, thus avoiding direct rays of the sun at midday; (6) leaves with very small cross-section; (7) small leaf surface; (8) ericoid, pinoid, or involute leaves; (9) thick outer epidermal walls; (10) inner epidermal walls mucilaginous, swelling more or less when water is taken up; (11) epidermal cells of large capacity, allowing considerable water storage; (12) leaf symmetry dorsiventral and radial; (13) long palisade cells; (14) spongy mesophyll much less open than in mesophytes; (15) a brown coloring matter, probably tannin, present in the strongly illuminated peripheral portions of the leaves, forming a protection against too strong light; (16) presence of hairs on the furrowed side of ericoid leaves and of the dorsiventral involute leaves to protect against excessive transpiration. Any given species ordinarily has but few of the above characteristics, and all plants do not have them developed to the same degree. Another set of characters is not general, but is confined to certain groups of plants. These special characters are given as follows: (1) depression of stomata; (2) hypodermal aqueous tissue; (3) internal aqueous tissue; (4) sclerenchyma, which increases the rigidity of the aqueous and chlorophyll tissues; (5) oil reservoirs; (6) bud scales.—H. C. C.

[13] Bot. Centralb. **67**: 391. 1896.

F. DELPINO has just published [14] a discussion upon the classification of monocotyledons, based upon certain new criteria. A review by Solla [15] furnishes the basis for the following statement of his views. Engler's classification [16] of 1892 has seemed to morphological taxonomists to be by far the most natural one yet proposed, and it remains to be seen whether Delpino has proposed anything better in the way of natural grouping. He recognizes the two monocotyledonous groups, the eucyclic (trimerous pentacyclic floral structure) and the polycyclic (unstable floral structure and varying number of whorls). The eucyclic monocotyls are not regarded as primitive, but as derived from the polycyclic groups, which are believed to be the "connecting link" between eucyclic monocotyls and dicotyls. In both the monocotyl groups there are forms which have retrograded, giving rise to four taxonomic groups, viz. normal and reduced polycyclic forms, and normal and abnormal eucyclic forms.

The group of "normal polycyclic monocotyls" includes Alismaceæ, Butomaceæ, and the higher genera of the Hydrocharideæ. The author makes the Butomaceæ his starting point, and considers *Butomus umbellatus* to be the oldest form, because it resembles several polycyclic dicotyls. Connected with these is the group of "reduced polycyclic monocotyls," which includes the lower Hydrocharideæ, Juncagineæ, Aponogetonaceæ, Potamogetonaceæ, and Naiadaceæ.

The "eucyclic monocotyls" include all the rest of the families with pentacyclic structure. The nectary furnishes a biological and phylogenetic character by which they are subdivided into three groups: the *Anadenien*, which have no nectaries; the *Carpadenien*, which have nectaries in connection with the carpels; and the *Petaladenien*, which have nectaries in connection with the floral leaves.

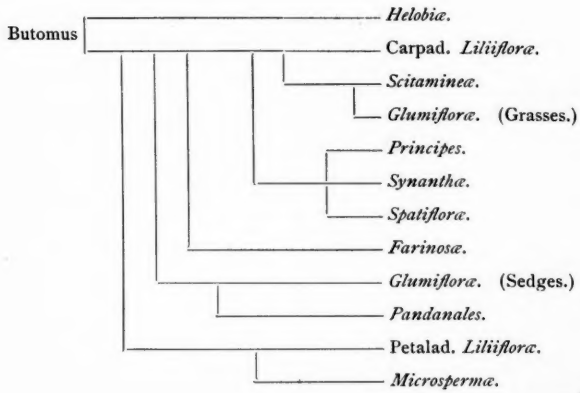
The author regards the leaves as of taxonomic value in large groupings. These groups are as follows: (1) those with sword-shaped leaves, subdivided into Gladiatæ and Hemigladiatæ; (2) those with three-sided leaves, all of which may be derived from the genus Dracæna; (3) those with ligules (Gramineæ, etc.)

It will be noted that Delpino, like Engler, makes two groups of monocotyls, but only the Helobiæ are regarded as polycyclic, all the rest being eucyclic. The author also regards monocotyls as monophyletic, while Engler's scheme makes them triphyletic. The following tabular statement presents Delpino's scheme, which certainly has the merit of being quite different from others.

[14] Mem. Real. Accad. Sci. Bologna V. **6**: 83–116. 1896.

[15] Bot. Centralb. **67**: 370. 1896.

[16] Die systematische Anordnung der monokotyledoneen Angiospermen: Abhandl. König. Preuss. Akad. Wissen. Berlin, 1892.



—C. J. C.

ALTHOUGH THE EXISTENCE of acid secretions by roots has been known for nearly forty years, no exact knowledge of the chemical composition of these secretions was at hand. To fill this gap, and to reinvestigate the opinion of Molisch that diastatic and inverting enzymes are secreted by the root, Czapek undertook the investigations to which brief reference has already been made on p. 65 of this volume. In the full paper[17] the excretions of roots are exhaustively discussed. A translation of the author's own summary is here given.

The roots of the higher plants, under culture either in a saturated atmosphere or in water, secrete a series of dissolved substances, partly inorganic, partly organic.

The droplets which are generally seen on root hairs in a saturated atmosphere are produced by filtration under pressure, and appear only when the hair cells are highly turgescent.

Of inorganic substances which roots give off in water may be named: potassium, calcium, magnesium, hydrochloric acid, sulfuric acid and phosphoric acid. Only potassium and phosphoric acid are present in any considerable quantity; they are found in the form of primary potassium phosphate, in many cases by far the predominant constituent of the residuum upon evaporating the root excretions.

The mono-potassium phosphate (KH_2PO_4) arises in all probability in great part from living cells of root hairs, the epidermis, and the outer cortex in the piliferous region.

Neither acetic acid nor lactic acid, as was asserted on many sides, is found in the root excretions. Formic acid, in the form of its potassium salt, is of not

[17] Jahrbücher f. wiss. Botanik **29**: 321–390. 1896.

uncommon occurrence. It diffuses from living cells in the youngest part of the root and is therefore not a product of destructive processes.

The detection of oxalic acid as primary potassium oxalate is at present limited to the excretions of the root of *Hyacinthus orientalis*.

The well known permanent reddening of litmus paper depends as a rule upon the acid reaction of mono-potassium phosphate. Its intensity varies, and these differences are parallel with the amount of phosphate excreted. The acid reaction of the hyacinth roots to litmus paper has, on the contrary, another source, which is referable to the primary oxalate.

If the phenomena of the corrosion of stone plates by roots are studied by using artificially prepared plates consisting of substances of known solubility in certain acids, it becomes evident that the carbonic acid excreted must play the principal rôle in all the etching observed. One may say in general that substances which cannot be dissolved by carbonic acid cannot be attacked to any extent by the root excretions, so that corrosive action does not appear. It is to be observed that we have to deal not with the action of carbonic acid in free gaseous condition, but with the solvent actions of fluid saturated with carbonic acid, as the water of imbibition of the outer layers of the membrane of the root cells and the adjacent films of the soil water. Moreover, all known phenomena of corrosion can be completely explained by the action of carbonic acid. Hence it results that the reddening of litmus and the corrosion of stones depend upon the action not of the same but of two different substances (mono-potassium phosphate and carbonic acid). No other free acid is secreted, normally at least, by roots. Acid action upon the substratum by substances secreted by roots, however, is probable from a series of empirically established facts, and it occurs, as a matter of fact, without relation to the effects produced by carbonic acid. The mono-potassium phosphate excreted by the roots takes a prominent part in bringing about this action, since it enters into reaction with neutral salts of the stronger acids and thus leads to the production of smaller amounts of the mineral acids concerned. Especially is this the case with the chlorides and the formation of hydrochloric acid. A condition for such acid action upon the substratum is that the dissociated neutral salt shall not be readily taken up and consumed by the plant, but may enter in more or less undiminished amount into reaction with the phosphate. Naturally the amounts of acids thus formed are very small, yet they are sufficient in a long period of time to produce noteworthy effects in large masses of soil thoroughly permeated by roots, by means of which its insoluble constituents are unlocked and made available to plants.

An excretion of diastatic or inverting enzymes by the roots is physiologically not inconceivable, but certainly does not occur normally. Critical repetition of the researches of Molisch, who has asserted a normal occurrence of these ferments in root secretions, shows instead a negative result when one carefully considers the sources of error.— C. R. B.

THE ANATOMY of the vascular plants has been treated from the standpoint of physiology by several writers, notably Schwendener and Haberlandt. The comparative anatomy of the lower plants has dwelt chiefly upon the reproductive processes. Istvánffi published in 1891 in Hungarian a short paper entitled "Contributions to the physiological anatomy of fungi," [18] and now offers a further contribution [19] in which he pays particular attention to the conducting system in the Hydneæ, Thelephoreæ, and Tomentelleæ. Necessarily he deals chiefly with the fructifications.

Following the general plan of Schwendener and Haberlandt he classifies the false tissues of the fungi into four systems: (1) the merismatic, (2) the protective, (3) the nutritive, (4) the reproductive.

The tissues corresponding to the meristem of higher plants are very rarely differentiated. The tips of many rhizomorphs, as in *Armillaria mellea*, show an extraordinary resemblance to the tips of phanerogamous roots, which is heightened by the mucilaginous sheath, corresponding to the root cap. Besides these growing points may be enumerated the merismatic pycnidia, the margin of the pileus and similar growth zones.

The protective system is manifold. (1) To the epidermal system are to be referred the superficial tissues, whether formed of parallel hyphæ or of pseudo-parenchyma; the various scales and similar structures of the higher Hymenomycetes; the cortex, which may be as much as four-layered, as in *Lactarius resimus;* the colossal cortex of the woody *Polypori;* the paraphyses and cystidia which prevent the stripping of the spores and are often stiffened by mineralization; and the various thickenings about sporangia and spores. (2) The mechanical system includes all arrangements for maintaining bodily form. These are: in single celled species the elasticity of walls and turgor; in multicellular ones transverse walls; thickening of walls; the protective tissues, sometimes forming an outer skeleton; the rosette-like or cylindrical groups of bladdery hyphæ as in the Agaricineæ; and the palisade-like grouping of the basidia.

The nutritive system includes (1) an absorptive system, (2) a conducting system, (3) a storage system, (4) an aerating system, and (5) an excretory and secretory system.

The absorptive tissues include the general mycelium when submerged, the haustoria and appressoria, and the various compound forms into which hyphæ are united (bands, cords, strands, or membranes), serving also a mechanical function.

The conducting system, to which Istvánffi has given chief attention by

[18] Adatok a gombák physiologiai anatomiájához, Természetrajzi Füzetek **15**: 52–67. *pl. 1.* 1891.

[19] Untersuchungen über die physiologische Anatomie der Pilze mit besonderer Berücksichtigung des Leitungssystems bei den Hydnei, Thelephorei und Tomentellei, Jahrb. f. wiss. Botanik **29**: 391–440. *pls. 5.* 1896.

detailed descriptions, includes the structures generally known as latex and oil reservoirs, and vascular hyphæ. These contain both plastic and by products of metabolism. They are emptied in connection with the formation of the fructification. The elements of the conducting system are short club shaped cells, or long thin tubes, or very long much branched and anastomosing tubes, all multinucleate. They arise as lateral outgrowths from the ordinary hyphæ and when mature have many connections with them. When the fructification is very young they form a dense coil in the center. In rhizomorphs and band like mycelia they appear in a similar way. There is no regularity in their distribution, but they usually form one or several layers at the margin of the stipe and beneath the hymenium.

Since the earlier researches of Istvánffi and Olsen, Van Bembeke has examined fifty-three species of ten families and Istvánffi sixty species of the three families above named, both European and exotic. The extent of these researches justify a classification of the elements of the conducting system into six groups, the first five of which include the tubular reservoirs: (1) *Hymenochaete* type, undulate, with pointed ends protruding from the hymenium; (2) wholly internal (only in two species); (3) *Stereum* type, parallel with the surface, bending out into the hymenium, their ends not or scarcely swollen: (4) *Thelephora* type, vertical to the surface, often in several zones; (5) *Corticium* type, in several layers, the ends clubbed (*keulig aufgeschwollen*); (6) round reservoirs.

A considerable number of examples of each of these types are described in detail. Istvánffi thinks the character of the conducting system may be used systematically.

The storage system of tissues includes chiefly the sclerotia.

To the aerating system are referred the air spaces in the interior of the stipe and pileus, as in Agaricineæ and Phalloideæ, which increase in size toward the center.

The excretory and secretory system comprehends the structures excreting resin-like materials, reservoirs of coloring matters and poisons, a part of the cystidia (especially those with crystalline contents), and the glandular hairs upon the absorbing system of *Schizophyllum* spp.—C. R. B.

NEWS.

DR. F. CZAPEK has been called to the assistant professorship of botany and technical microscopy in the German Institute of Technology in Prag.

PROF. DR. HUGO DE VRIES has been called to the directorate of the botanical garden at Amsterdam made vacant by the recent retirement of Dr. Oudemans.

PROF. DR. K. MÜLLER of the royal school of technology at Berlin has undertaken, as a side duty, the botanical instruction in the royal horticultural institute in Potsdam-Wildpark.

PRINCETON UNIVERSITY at its recent sesquicentennial conferred the degree LL.D. upon George Lincoln Goodale, Fisher professor of natural history and director of the botanical garden in Harvard University.

DR. A. HANSGIRG will discuss in a large work which he is preparing for the press, upon the general lines of his *Phytodynamische Untersuchungen*, ombrophoby in flowers, resistance of pollen to water, gamo- and carpotropic movements, and similar curvatures.

THE CATALOGUE of microscopes and laboratory apparatus just issued by the Bausch & Lomb Optical Co. is more than a mere trade list and will well repay examination by those interested in laboratory appliances. Among the novelties the Hastings' aplanatic triplets and the attachable mechanical stage may be commended most heartily.

ON OCTOBER 10th the botanical seminar of the University of Nebraska celebrated its decennial. There have been only twenty members of various ranks in the ten years, of whom ten are in residence in 1896. It is truly remarkable how much valuable work this society has done under the inspiration of its indefatigable leader, Dr. Bessey.

THE TREE, *Saccoglottis Amazonica* Martius, which produces one of the "drift fruits" that long puzzled West Indian botanists, has been rediscovered upon Trinidad. The source of the fruits was established by the sketches of Crüger who collected specimens of the tree upon Trinidad years ago. The superintendent of the Trinidad gardens, Mr. J. H. Hart, sent a collector to hunt up the trees, and after two expeditions he was successful in securing not only good herbarium specimens but also flowers and fruits in alcohol, and seeds from which the gardens have raised some healthy plants.

GENERAL INDEX.

The most important classified entries will be found under Contributors, Diseases, Geographical Distribution, Personals, Reviews. Names of new species are printed in **bold-face** type; names of synonyms in *Italics*.

A

A. A. A. S., Botanical Club 171, 244, 264, 271; Buffalo meeting 171, 221; 1897 meeting 272; section G 171, 264, 271
Abies Arizonica 429; pectinata 235
Acanthus mollis 69
Achillea Millefolium 169
Acids, secretion by roots 508; toxic action of 81, 125
Adhesions, heredity of 345
Adiantum pedatum 410
Æcidium elatinum 235
Agaricus melleus 235, 510
Agricultural College of Florida damaged 430
Agricultural Department, Biological Survey 57; botanical work of 266; Division of Botany 418; scientific chief 57, 265, 417
Alabama, flora 80, 420; ferns of 228, 407
Algæ new to Great Britain 75
Allen's "Characeæ of America" 63
Alternaria Solani 246
Alternation of generations 425
Amblyodon dealbatus Americanus 51
Amelanchier, North American species of 234
Amphicarpum, Floridanum 403, 406; Purshii 403, 405, 406
Anatomy, of fungi 510; of Gramineæ 403; of pine leaf 435; of stem of Onagraceæ 229
Anderson, A. P., work of 235, 249, 251; personal 271, 430
Anemone, a new Californian 429
Anisophylly 68
Anomobryum, *concinnatum* 51; filiforme **Americanum** 51; *juliforme* 51; *sericeum* 51
Anther, abnormal 69
Anthracnoses in cultures 226
Anthurus 379, 390; borealis 273, 274, 284, 390
Antipodal cells 237
Aphyllon Ludovicianum 169
Apogamy in Ptilota 375
Apparatus, physiological 258, 463
Apple, relation of buds to light 424; root galls 424
Appressoria of Botrytis 329
Aquilegia Jonesii 345
Araceæ, heat of flowers 503
Arctostaphylos Uva-ursi 244
Arenaria paludicola 488
Arisaema, Dracontium 247; stigma and pollen 234; triphyllum 233
Armillaria mellea 510
Arnica, new species of 504
Arnold's "Labrador" 343
Arnoldi, W., work of 504
Arruda's Brazilian plants 75
Arthronia **aleuromela** 334
Arthur, J. C., 60, 61, 176, 243, 424, 427, 463, 502; personal 190
Ascobolus furfuraceus 304
Ascomycetes 301, 302
Ascospores of Pyrenomycetes 234
Asimina 161, 182
Askenasy, work of 183
Aspidium cristatum × marginale 429
Asplenium, angustifolium 411; Bradleyi 240; ebenoides 228, 350, 410; filix-fœmina 409; montanum 412; pinnatifidum 410, 412; platyneuron 409, 410; thelypteroides 411; Trichomanes 410
Aster, new species of 504
Astragalus, arrectus 489; **Palousensis** 489; raventus 489
Atkinson, G. F., work of 220; personal 271
Auxanometer 463

B

Bacteria, culture methods 246; of cheddar cheese 225; of squash bug 236
Bactris speciosa 503
Bailey, L. H., 401, 454; work of 221, 222; "Survival of the Unlike" 500

Baker, J. G., work of 344, 429; "Flora Capensis" 432
Bark, disease 76; what is 73, 237; in a tree trunk 54
Barnes, C. R., 55, 62, 64, 65, 66, 67, 178, 180, 181, 182, 183, 340, 341, 343, 344, 345, 500, 502, 503, 508, 510; personal 271; work of 226, 237, 248; "Keys to Mosses" 191
Basidiomycetes 305
Beal's "Report of Bot. Dept. Mich. Agric. Coll." 342
Bebb, M. S., personal 350
Beckwith, Florence, work of 250; and McCauley's "Flora of Monroe Co., N. Y." 340
Beet, effect of weight and size of seed 424
Berberis, Greene on 429; Nevinii 428
Bergen, Fannie D. 473
Bertrand, work of 65
Bessey, C. E., work of 224, 229, 245, 246, 248
Bibliography 213
Bicknell, E. P., work of 344
Bidens Beckii 490
Bignonia crucigera 244
Biological survey 57
Black knot of plum 424
Boletus *phalloides* 385
Books, new botanical 351
Boronia megastigma 69
Borzi, personal 430
Boschniakia, glabra 248; strobilacea 247
Botanical Society of America 171, 350; address of President 193; Buffalo meeting 218, 264, 271
Botrychium, bipinnata 228; biternatum 407; *lunarioides* 407; *ternatum var.* 407, 408; Virginianum 410
Botrypus *lunarioides* 407, 408
Botrytis, cinerea 503; vulgaris 329
Bowers, Homer, on Hydrastis 497
Branching of Griffithsia 37
Brassica, juncea 252, 401; Sinapistrum 252
Bray, W. L., personal 190
Brazil, flora of 272
Briquet, J., work of 76, 182
Britten, J., work of 75
Brittonastrum 76
Britton, Elizabeth G., work of 244, 247, 248, 251
Britton, N. L., address of 272; personal 271; work of 219, 222, 234, 238, 239; and Brown's "Illustrated Flora" 269, 417
Brodiæa, American and new Californian 429; synopsis 344
Brotherus, V. F., personal 76
Bryum, lucidum 248; *Sandbergii* 248
Buffalo (N. Y.) botanical garden 272
Buitenzorg botanical garden 350, 496
Bulletin, of experiment stations 424; of N. Y. Botanical Garden 77
Bupleurum Guineti, hybrid 182
Burgess, E. S., personal 271
Burrillia **globulifera** 414
Burt, E. A., 273, 379
Busch, N., personal 450
Butomus umbellatus 507

C

Cactus, *Brownii* 253; garden 431
Caldwell, O. W. 504
Callicarpa Pringlei 182
Callithamnion, procarps and cystocarps of 370
Campanula, aurita 490; rotundifolia 67
Campbell, D. H., personal 190, 271
Camptosorus rhizophyllus 410
Canna, morphology of flower 222
Cardamine, arenicola 239; **callosicrenata** 488; flexuosa 239; hirsuta 239; parviflora 239; Pennsylvanica 239
Cardot, J., 48; work of 344
Caromyces *elegans* 380, 381
Carotin 66
Carpogonium 36
Cassia, anthers 69; Chamæcrista 236; a new 236
Casuarina Covillei 438
Catalpa, anther 69
Catasetum tridentatum 505
Caulophyllum 164; thalictroides 154
Centrifuge 466
Cephalozia, revision of 429
Ceramium, decurrens 44; procarps and cystocarps of 370
Ceratostoma breviroste 234, 317
Ceratozamialongi folia 503
Cercospora, Diospyri 502; *flexuosa* 502
Ceres pulver 238
Chalazogamy 227
Chamæcyparis 183; *Lawsoniana* 184; *Nutkaënsis* 184; *sphæroidea* 184
Chamberlain, C. J. 69, 426, 507
Champia parvula 45
Characeæ, nuclear division 77
Cheese, bacteria of 225
Cheilanthes lanosa 409
Chicago, University of, botanical laboratory 78
Chlorophyll, alteration of 438; reaction for 65
Chrysopsis, new species of 504
Cinnamomeæ, section of Rosa 4

Citharexylum Jurgenseni 183
Clathreæ 379, 388
Clathrus 379, 388; *albus* 389; *Angolensis* 388; *australis* 388; *Berkeleyi* 388; *Brasiliensis* 388; cancellatus 277, 280, 285, 389; *cancellatus vars.* 388; *colonarius* 388; columnatus 273, 388; *flavescens* 389; *Nicæensis* 389; *ruber* 389; *triscapus* 388; *violaceus* 389
Clematis Addisonii 345
Clinostat 259
Cnicus altissimus, fasciated 431
Cockerell, T. D. A., 268
Cohesions, heredity of 345
Coleosanthus, new species of 504
Coleosporium Pini 433
Colletotrichum 226
Colonnaria *urceolata* 388; *truncata* 388
Color, physiology of 65, 66, 74, 428a
Colorado, flora of 246
Comandra umbellata 249
Comes, O., work of 191
Compass plant, another 491
Compositæ, Greene on 79; new 182
Coniferæ, abnormal resin ducts 235; adaptation to wind 250
Connecticut, new species of Prunus 240
Contributors: Arthur, J. C. 60, 61, 176, 423, 424, 427, 463, 502; Bailey, L. H. 401, 454; Barnes, C. R. 55, 62, 64, 65, 66, 67, 178, 180, 182, 183, 340, 341, 342, 343, 344, 345, 500, 502, 503, 508, 510; Bergen, Fannie D. 473; Burt, E. A. 273, 379; Caldwell, O. W. 504; Cardot, J. 48; Chamberlain, C. J. 69, 426; Cockerell, T. D. A. 268; Coulter, J. M. 59, 60, 63, 64, 173, 177, 179, 180, 181, 182, 183, 269, 340, 345, 346, 347, 348, 422, 425, 428; Coville, F. V. 418; Cowles, H. C. 506; Crépin, F. 1; Davenport, G. E. 497; Davis, B. M. 353; Davis, J. J. 413; Deane, W. 166; Earle, F. S. 255; Galloway, B. T. 266, 417, 433, 496; Glatfelter, N. M. 392; Greenman, J. M. 168; Gregory, Emily L. 72; Heald, F. D. 125; Holm, Theo. 403, 417; Horn, Margaretha E. C. 329; Kahlenberg, L. 81; Kelsey, F. D. 54; MacDougal, D. T. 188, 293, 496, 498; Mell, P. H. 420; Merrell, W. D. 426; Millspaugh, C. F. 333; Mitchell, W. R. 505; Nichols, Mary A. 301; Nuttall, L. W. 333; Peirce, G. J. 184; Piper, C. V. 488, 491; Pound, Roscoe, 338; Rand, E. L. 267; Renauld, F. 48; Robertson, Chas. 154; Robinson, B. L. 166, 168, 252; Smith, Anna A. 35. 402; Stone, G. E. 258; Stuntz, S. C, 503; Toumey, J. W. 253; Trelease, Wm. 193; True, R. H. 81; Underwood, L. M. 255, 407; Wettstein, Richard von 401
Cook, O. F., personal 271
Copeland, E. B., personal 271; work of 243, 249, 250
Coprinus, revision 346
Cordylanthus pilosus *trifidus* 168
Cork, of wounds 77
Corn, diseases of 424; roots of 227
Corynites *brevis* 381, 382, 383; *Curtisii* 380, 381; *elegans* 380; *Ravenelii* 381, 382, 383
Coulter, J. M. 59, 60, 63, 64, 173, 177, 179, 180, 181, 182, 183, 269, 340, 345, 346, 347, 348, 422, 425, 428, 503; personal 271; work of 227, 237, 251; "Flora of Texas" 191
Coville, F. V. 418; personal 271; work of 503
Cowell, J. F., personal 272; work of 248
Cowles, H. C. 506
Cratægus, coccinea and allies 222; flabellata 222; macracantha 222; mollis 222; new species of 504; parvifolia 257; rotundifolia 222; spathulata 255, 257
Crépin, François 1
Crepis barbigera 268
Cross fertilization and heterospory 251
Cultures of fungi 305, 329
Cupressus 183; North American species 184; *Arizonica* 184; Goveniana 184; *Guadalupensis* 184; Macnabiana 184
Cucurbita Pepo 126
Cynoglossum, new Californian 429
Cynophallus *caninus* 382
Cyperaceæ, new to North America 238
Cyperus, aristatus 238; comosus 238; congestus 238; cylindrostachyus 238; glaber 238; inflexus 238; pumilus 238; thyrsiflorus 238; ustulatus 347
Cypripedium, nuclear budding 250
Cystocarp, development in Griffithsia 35, 235; in Ptilota 353
Cystopus candidus 426
Czapek, F., personal 512; work of 65, 508

D

Dangeard, work of 182
Davenport, G. E. 497; work of 429
Davidson's "Catalogue of Plants of Los Angeles Co., California" 343
Davis, B. M. 353
Davis, J. J. 413
Day, D. F., work of 241, 244; personal 272

Day, R. N., work of 222
Deane, Walter 166; "Flora of Boston Parks" 64
Degrees, advanced 205
Delphinium, Greene on 429
Delpino, F., work of 507
Descurainea 429
Dewey's "Tumbling mustard" 180
Dicotyledons and monocotyledons, divergence of 229
Dictyophora 379, 385; duplicata 273, 283, 384, 385, 386, 387; *phalloidea var.* 387; Ravenelii 385, 386
Dicranum **Demetrii** 48; fuscescens Eatoni 49; **subfulvum** 49; **trachyphyllum** 48
Diels's "Vegetations Biologie von Neu Seeland" 341
Dippel, L., personal 191
Discomycetes 303
Diseases: anthracnose, cultures of 226; bacterial, of squash bug 236; black knot of plum 424; of corn 424; of larch bark 76; laws for prevention of 351; peach yellows 424; of pine 232, 433; of pine, supposed 251; of potato 246, 424; resin ducts from 235; root galls of apple 424; rust of asparagus 351, of pine 433; smut, fungicide 238; smut, a new 413; of turnips 503
Distegia 182
Dolosanthus 182
Draba aureola 488
Dryopteris, acrostichoides 409; Floridana 228, 407; marginalis 410; Noveboracensis 409; patens 409; spinulosa intermedia 411; Thelypteris 409
Duggar, B. M., work of 236
Durand, E. J., work of 241, 247, 249
Dynamometer, spring 261

E

Earle, F. S. 255; personal 76; work of 75, 222, 232, 502
Eastwood, Alice, work of 344, 429
Eaton and Faxon's "Sphagna Bor.-Am. Exsiccata" 502
Echinocactus Simpsoni 254
Ecology, of African woody plants 506; in garden 191; place in secondary schools 493
Egg apparatus 237
Electric slide 471
Electrolytic dissociation of salts 81
Eleocharis, new to North America 219
Elm, bark enclosed 54
Elmore's "Classification of Diatoms" 502
Elytraria virgata **angustifolia** 169
Embryo-sac structures 237
Empetrum nigrum 491
Endosperm 237
Endotrophy 68
Engler and Prantl's "Natürlichen Pflanzenfamilien" 76
Enzymes, production by roots 508
Epidermal tissues of fungi 510
Epipactis viridiflora 247, 250
Epitrophy 68
Equipment for research 196
Erysimum arenicola 488
Erythronium, albidum 76; mesochoreum 76
Euonymus 160
Euphorbia 160
Euphrasia, Americana 401; hirtella 407; latifolia 401; nemorosa 401; Oakesii 401; officinalis 402
Evans' "Copper sulfate and germination" 343
Exotrophy 68
Experiment Stations, Agricultural, bulletins of 424

F

Fairchild, D. G., personal 190
Familler, I., work of 68
Farlow, W. G., personal 75
Fasciation, large 431
Ferns, of Alabama 407, 228; fronds of 497; sporophylls 220
Fertilization in Griffithsia 41; in Ptilota 372
Fissidens decipiens **Winonensis** 50
Fixing methods 37, 306
Flax, maceration of 182
Floras, local 267
Flowers, reduction of 70; and insects 70, 71, 154
Fontinalis, new species of 344
Forestry, course in 351; library at Biltmore 191
Forests, distribution 344; tertiary 349
Franchet, M. A., work of 344, 429
Fribes, V., work of 182
Frond, use of term 497
Funaria hygrometrica 249
Fungi 246, 249, 301, 433; comparative anatomy of 510; methods of growing 305; parasitic, of Mississippi 510; Pringle's Mexican 423; pure cultures 244
Fungicide, Jensen's 238
Fusarium acuminatum 424

G

Galloway, B. T., 266, 417, 433, 496; personal 271; "Frosts and freezes" 179; "Lines of investigation" 342

Gametangia 226
Ganong, W. F., personal 76
Gardens, botanical 202, 335; address on 272; Buffalo 272; Buitenzorg 350, 496; cactus 431; Innsbruck 191; Oxford 192
Gastrodia 347
Gatesia 429
Gaye's "Great World's Farm" 60
Geographical distribution: 218, 222, 224, 228, 236, 238, 240, 244, 245, 246, 247, 248, 250, 251, 252, 255, 341, 344, 347, 401, 407, 434, 488
Geotrophy 68
Germination, effect of alkali on 424; of Loranthaceæ 185; spores of Coleosporium 442
Gibbs, Gertrude, personal 431
Gibson, W. H., death of 192
Glatfelter, N. M. 392
Glœosporium 226
Glyceria fluitans 413
Gnomoniella 227
Goebel, C. E., work of 67
Goodale, G. L., personal 78, 512
Gramineæ, anatomical characters of 403; of Iowa 238
Greene, E. L., work of 76, 79, 429, 504
Greenman, J. M. 168
Gregory, Emily L. 72; work of 251
Griffithsia, cystocarp of 35, 235, 370; corallina 35, 36, 39, 43, 44
Grindelia, new species of 504
Growth, apparatus for root 261; causes of unequal 67; effect of alkali on 424; of leaves and CO_2 221; of roots in dilute salts 87, 125; and turgor 243
Gymnosporangium, distribution of in south 222, 255; Bermudianum 255, 256, 257, 258; clavipes 255, 256, 257; conicum 257; globosum 255, 256, 257; *Juniperi* 257; juniperinum 257; macropus 255, 256, 258; nidus-avis 255, 257
Gymnostomum calcareum **Winonense** 48
Gynæcium, reduced 70

H

Hansgirg, A., personal 512
Harper, R. A., personal 190
Harshberger, J. W., work of 75
Hart, J. H., work of 505
Haustoria of Loranthaceæ 186
Heald, F. D. 125
Heat produced in flowers 503
Helianthus annuus 345; hybrids 248
Heller, A. A., personal 75
Hemizonia **Congdonii** 169; Parryi 170
Hemsley, W. B., work of 504
Herbarium 198; dendrologicum 191; index cards for 251; National 247, 418; Contributions from National 340
Heredity of abnormalities 345
Heterophylly 67
Heterosphondylium 35
Heterospory 251
Heterotrophy 67
Heuchera, a new Californian 429
Hippuris montana 491
Hitchcock's "Kansas Grasses" 501; "Kansas Weeds" 179
Hollick, A., personal 271
Holm, Theo. 403, 417
Horn, M. E. C. 329
Hosackia, a new Californian 429
Hull Biological Laboratory 78
Hyacinthus orientalis 509
Hybrid, Bupleurum 182; fern 429; Lonicera 345; roses 7; Salix 75, 392; sunflower 248
Hydrastis Canadensis 498
Hydrotrophy 68
Hygrometer 470
Hymenogaster decorus 290
Hymenophallus, *duplicatus* 387; *Hadriani* 384; *togatus* 387
Hyphæ, vascular 510
Hypnum, cordifolium 53; chrysophyllum brevifolium 52; cupressiforme 52; eugyrium 52; hamulosum 52; **implexum** 52; orbiculari-cordatum 52; palustre 52; **subeugyrium** 52
Hypochæris glabra 345
Hypocopra 325
Hypotrophy 68
Hysterangium clathroides 290

I

Ilysanthes 344
Imbedding 245
Insects and flowers, see Flowers and insects
Innsbruck botanical garden 191
Iowa, Bulletin State Laboratories of Natural History 64; forest distribution in 344; grasses 238
Iris, branching rhizomes 244
Irritability 242, 243, 293, 427, 504, 505
Isoetes malinvernania 504
Islands, flora of fresh water 218
Istvánffi, G., work of 510
Ithyphallus 379, 383; *cucullatus* 385; impudicus 384; *Ravenelii* 385; rubicundus 384, 385

J

Jack, J. G., personal 351
Jones, L. R., personal 271; work of 244, 246
Josselyn botanical society of Maine 77
Journal Milwaukee Brewing Academy 351
Juncus, confusus 504; tenuis 504

K

Kahlenberg, L. 81
Kaiser, Otto, work of 77
Keeble, F. W., work of 184
Kellerman, W. A., personal 271; work of 238, 244, 251
Kelsey, F. D. 54
Kirk, T., work of 347
Klatt, F. W., work of 182
Knerr, E. B., work of 76
Knoblauch, E., work of 506
Knowlton, F. H., work of 349
Koehne's "Herbarium dendrologicum" 191
Kohl, F., personal 350
Kraus, G., work of 503

L

Labiatæ 76
Laboratory, an American tropical 415, 494, 496; appliances 258, 463; equipment 196; international at Palermo 430; research in American 188
Lactarius resimus 510
Lactuca Scariola 253
Larch disease 76
Laternea, *Angolensis* 388; *columnata* 388; *pusilla* 388; *triscapa* 388
Latex reservoirs in fungi 511
Lawson, M. A., death of 430
Leaves, casting of pine 433; excretion of water by 503; of ferns 497; function of submerged in Salvinia 249; growth of 221; influence of light on form 67; length of life of pine 437; position of 222; relation to rainfall 232
Lecanora **deplanans** 334
Lecidea, **Nuttallii** 334; **Virginiensis** 333
Leiophallus 384
Lejolisia, procarps and cystocarps of 370
Lepidesmia 182
Lepiota Morgani 430
Leptostroma vestita 423
Libocedrus 183
Library 193; of forestry at Biltmore 191
Light, effect on mesophyll 436; effect on Wyethia 491; influence on form of leaves 67; relation of buds to 424
Lilium, candidum 330; Martagon 426
Lindauea 428
Lindman, C. A. M., personal 272
Linnean Society, 40th meeting 192
Linum, staminodia 69
Lippia Pringlei 182
Littledalea 504
Lloyd's "Photogravures of American Fungi" 75, 430
Lodeman's "Spraying of Plants" 61
Lonicera, hirsuta 345; hybrid 345; new Chinese 429
Loranthaceæ of Ceylon 184
Loranthus loniceroides 185
Lupinus, albus 87, 125, 243; new Californian 429
Lysurus Texensis 391

M

Macbride, T. H., work of 344
MacDougal, D. T. 188, 293, 496, 498; personal 190; work of 75, 221, 232, 243, 427, 505
MacMillan, C., work of 218, 249, 250, 425
Macrosporium, *Solani* 246; *Tomato* 246
Macrozamia Mackenzi 503
Maiden, J. H., personal 350
Maine, botanical society of 77
Malèvre, work of 65
Malme, G. O. A., personal 272
Mamillaria **Brownii** 253; macromeris 254
Massee, Geo., work of 346
Masters, M. T., work of 183
Mathews's "Familiar Flowers" 180; "Familiar Trees" 342
Meehania 76
Mell, P. H. 420; "Flora of Alabama" 80, 420
Mentzelia, new species of 504
Mercury, reservoir for 471
Meristem of fungi 510
Merrell, W. D. 426
Merriam, C. H., work of 429
Mesomycetes 301
Mexican botanical club 272
Microscope, horizontal 55
Millspaugh, C. F. 333
Mimosa, mechanism of movement 293
Minks's "Protrophie" 340
Mississippi, a new Cassia from 236; parasitic fungi of 502
Missouri botanical garden, damage to 79; a new Viburnum from 166
Mitchell, W. R. 505
Mitford's "Bamboo Garden" 177
Mnium, cuspidatum 249; *Roellii* 248
Mohr, Charles, work of 80, 420
Molisch, H., work of 65, 66

Monactinocephalus 182
Monocotyledons, classification of 507; and dicotyledons, divergence of 229
Montana mosses 251
Morgan's "Myxomycetes of Ohio" 422
Morphology, place of in secondary schools 493
Mosely, E. L., work of 224
Mosses 244, 248: new North American, 48, 344; turgor in 249; of Williams 251
Mueller, F. von, death of 432
Mueller, Karl, personal 350, 512
Mulford's "Agaves of U. S." 59
Murrill, W. A., personal 350
Muscari comosum 70
Mutinus 379, 380; *bovinus* 380, 381; *brevis* 381; caninus, 273, 283, 381, 382, 383; Curtisii 380; *elegans* 380; *Ravenelii* 381, 382, 383

N

Naccaria 45
Nageiopsis 349
Names, popular 473
Nash, Geo., work of 182
Nasturtium *lacustre* 429
Nebraska, cañon flora 248; plants of 245; University of, botanical seminar 512
Nelson's "Flora of Wyoming" 180
Neobeckia aquatica 429
Nephropetalum Pringlei 168
Nestler, work of 503
Newcombe, F. C., personal 271; work of 242, 245
New York, botanic garden 77; flora of Erie Co. 224; flora of Monroe Co. 250
New Zealand flora 341, 347
Nichols, Mary A. 301; work of 234
Nicotiana, Comes on 191
Nomenclature 338, 352, 417, 432
North Carolina, flora of mountains 240
Nucleophaga Amœbæ 182
Nucleus, budding 250; of Cystopus 426; division of 77; of fungi 301; parasite of 182; sexual in Lilium 426
Nutation, apparatus for 262
Nuttall, L. W. 333

O

Oaks, notes on 245
Œnothera, Small on 79
Ohio, distribution of plants of 244; flora of Erie Co. 224
Oil reservoirs in fungi 510
Onagraceæ, anatomy of stem of 229
Onoclea sensibilis 409
Ophioglossum crotalophoroides 409
Opuntia, a new 429
Orobanche, *cærulea* 169; purpurea 169
Osmunda, *biternata* 407, 408; cinnamomea 409; regalis 409
Osterhout, W. J. V., personal 190
Ovary, significance of compound 224
Ovules, reduced 70
Oxford botanic garden 192

P

Palæobotany 348
Palms, collection of 350
Pammel, L. H., work of 238
Paraffin bath, improvement in 245
Parnassia 344
Parthenogenesis in Thalictrum 241
Pasteur monument 272
Pastinaca 160
Peach yellows 424
Peck, C. H., personal 271
Pectase 65
Pectin, action of pectase on 65; ferment 182
Peirce, G. J. 184
Pellæa atropurpurea 411
Pentstemon **Whitedii** 490
Peridermium on pine 232
Personals: Anderson, 271, 430; Arthur 190; Atkinson 271; Barnes 271; Bebb 350; Borzi 430; Bray 190; Britton 271; Brotherus 76; Busch 350; Burgess 271; Campbell 190, 271; Cook 271; Copeland 271; Coulter 271; Coville 271; Cowell 272; Czapek 512; Day 272; Dippell 191; Earle 76; Fairchild 190; Farlow 75; Galloway 271, Ganong 76; Gibbs 431; Gibson 192; Goodale 78, 512; Hansgirg, 512; Harper 190; Heller 75; Hollick 271; Jack 351; Jones, 271; Lawson 430; Lindman 272; Kellerman 271; Kohl 350; MacDougal 190; Maiden 350; Malme 272; Mueller, F. von 432; Mueller, K. 350, 512; Murrill 350; Newcombe 271; Osterhout 190; Peck 271; Prentiss 271; Regnell 272; Richards 430; Robinson 271; Rolfs 431; Sargent 76, 271; Schenck 191; Smith 431; Swingle 430; Tracy 271; Trécul 432; Trelease 75; Treub 190; Trimen 431; Vries 512; Waite 350; Westermaier 350; Williams 75; Willis 190; Wright 430; Zimmermann 350
Pestalozzia Hartigii 235
Petrocelis 45
Peziza, symbiosis of 75; Stevensoniana 304; vesiculosa 304; Willkommi 76

Pezizineæ 241
Phalleæ 379, 380
Phallogaster saccatus 290
Phalloideæ of United States 273, 379
Phallus *caninus* 381; *dæmonum* 387; *duplicatus* 387; *fœtidus* 384; *impudicus* 384; *inodorus* 381; *Ravenelii* 385; *rubicundus* 384, 385; *vulgaris* 384
Phegopteris hexagonoptera 409
Phelipæa cærulea 169
Phleum pratense 249
Philonotis tenella **Coloradensis** 51
Phoma abietina 235
Phormium tenax 347
Phoradendron flavescens 244
Photosyntax vs. photosynthesis 248
Phototrophy 68
Phycomycetes 301
Physalis, Rydberg on 422
Physiological apparatus 55, 258, 463
Phytophthora on potato 424
Picea excelsa 235
Pinchot and Graves's "White Pine" 64
Pine, Coleosporium on 433; Peridermium on 232; supposed disease of 251
Pinguicula vulgaris 491
Pinus, ponderosa 245; Strobus 235; sylvestris 235; Virginiana 433
Piper, C. V. 488, 491
Pisum sativum 126
Pohl, Julius, on Hydrastis 497
Pollard, C. L., work of 76, 236, 247
Pollen of Arisæma 234
Pollination of Loranthaceæ 184
Pollinia of Catasetum 505
Polygonella, revision of 429; and Thysanella 240
Polypodium, polypodioides 244, 409; vulgare 411
Polysiphonia, nigrescens 44; fastigiata 44; violacea 44
Populus, geological history of 349
Porter, Edna M., work of 250
Potato, diseases of 424; leaf fungi of 246
Potentilla 182; new species 429; Norvegica 249
Potter, M. C., work of 503
Pound, Roscoe 338
Prentiss, A. N., death of 271; biography 430
Pringle's Mexican Fungi 423
Procarp, of Griffithsia 35; of Ptilota 353
Prothallium of Isoetes and Selaginella 504
Protrubera Maracuja 291
Prunus, maritima 240; new species of 240
Pseudo-parenchyma 249
Ptelea trifoliata 155, 162
Pteris, aquilina 409; esculenta 347
Pterothamnion, procarps and cystocarps of 370
Ptilota, plumosa 353, 366; plumosa filicina 353, 366; serrata 353
Ptilothamnion, procarps and cystocarps of 370
Publication 206, 214; duplication of 336
Puccinia, Asparagi 351; Tetramerii 423
Pumpkin, indigenous to America 75
Pyrenomycetes 301; ascospores of 234
Pyrus, Americana 462; angustifolia 462; hortulana 461, 462; Ioensis 461; Malus 461; Soulardi 461, 462

Q

Quercus nana 241

R

Ramaley, F., work of 229
Rand, E. L., 267
Ranunculus, Greene on 428
Reed's "Kansas Mosses" 342
Regnell, A., personal 272
Renauld, F. 48
Reproduction, vegetative and non-sexual 226
Research, in American laboratories 188; equipment 196; notes of 211
Resin ducts, abnormal 235; of pine leaf 436
Respiration, adaptation for 243; heat produced by 503
Respirometer 468
Retinospora 183
Reviews: Allen's "Characeæ of America" 63; Arnold's "Labrador" 343; Bailey's "Survival of the Unlike" 500; Baker's "Flora Capensis" 432; Beal's "Report of Botanical Department" 342; Beckwith and Macauley's "Flora of Monroe Co., N. Y." 340; Britton and Brown's "Illustrated Flora" 269, 417; Bulletins of Agricultural Experiment Stations 424; Davidson's "Catalogue of Plants of Los Angeles Co., Calif." 343; Deane's "Flora of Boston Parks" 64; Dewey's "Tumbling Mustard" 180; Diels's "Vegetations Biologie von Neu Seeland" 341; Eaton and Faxon's "Sphagna Bor.-Am. Exsiccata" 502; Engler and Prantl's "Natürlichen Pflanzenfamilien" 76; Evans's "Copper sulfate and germination" 343; Galloway's "Frosts and freezes" 179; Galloway's "Lines of Investigation" 342; Gaye's "Great World's Farm" 60; Hitchcock's

"Kansas Grasses" 501, "Kansas Weeds" 179; Lloyd's "Photogravures of American Fungi" 75, 430; Lodeman's "Spraying of Plants" 61; Mathews's "Familiar Flowers" 180; Mathews's "Familiar Trees" 342; Mell's "Flora of Alabama" 80, 420; Minks's "Protrophie" 340; Mitford's "Bamboo Garden" 177; Morgan's "Myxomycetes of Ohio" 422; Mulford's "Agaves of United States" 59; Nelson's "Flora of Wyoming" 180; Pinchot and Graves's "White Pine" 64; Reed's "Kansas Mosses" 342; Rydberg's "Flora of the Black Hills" 181; Rydberg's "North American Species of Physalis" 422; Scribner's "Grasses" 430, 502; Smith's "Fodder and Forage Plants" 343; Strasburger-Noll-Schenck-Schimper's "Lehrbuch der Botanik" 178; Thompson's "Ligulate Wolffias of United States" 60: Trelease's "Juglandaceæ of United States" 59; Waters's "Erysipheæ of Riley Co., Kansas" 501; Webber's "Pineapple Industry" 180; Westermaier's "Compendium of General Botany" 176; Willkomm's "Pflanzenverbreitung iberischen Halbinsel" 63

Rhamnus 157, 160: cathartica 157; Frangula 157; lanceolata 157; pumila 157; saxatilis 157; tinctoria 157

Rheotropism 242

Rhizomes, branching of Iris 244

Rhododendron, Catawbiense 241; Vaseyi 345

Rhodomela subfusca 44

Rhus, *aromatica* 161; Canadensis 161; copallina 160; Cotinus 70, 159, 160, 161; glabra 160, 161, 162; Toxicodendron 160; typhina 159; venenata 160

Ribes, erythrocarpum 503; prostratum 489

Ridgway, Robert, work of 429

Ridley, H. N., work of 344

Richards, H. M., personal 430

Robertson, Charles 154

Robinson, B. L., 166, 252; personal 271; work of 345

Roentgen rays and plants 430

Rolfs, P. H., personal 431

Roots, excretions of 65, 508; galls of apple 424; growth, apparatus for 261; growth in dilute salts 87, 125

Roripa, Greene on 429

Rosa, observations on the genus in North America 1; acicularis 2, 7, 13, 16, 17, 21, 25, 26, 27, 28, 29, 32; acicularis Bourgeauiana 26; Alberti 31; Aleutensis 11; *arguta* 14; *Arkansana* 2, 12, 13, 14, 28, 29, 33; Beggeriana 31; blanda 2, 7, 9, 10, 12, 13, 14, 15, 17, 18, 19, 21, 25, 26, 28, 29, 33; blanda setigera 14; *Bourgeauiana* 27; *Bridgesii* 26; Californica 9, 10, 11, 15, 17, 19, 20, 21, 22, 23, 24, 25, 26, 33; Californica glabra 22; Californica ultramontana 24; canina 21; Carolina 3, 7, 10; Engelmanni 2, 27; Fendleri 2, 15, 16, 17, 21, 22, 23; foliolosa 3, 14; gratissima 19, 20, 21, 32, 34; gymnocarpa 3, 7, 14, 30, 31, 32, 33; gymnocarpa pubescens 30; humilis 2, 3, 7, 10; *lucida* 2, 3, 7; *Macdougali* 7, 8; *Maximiliana* 19; *megacarpa* 14; Mexicana 2; minutifolia 3, 32; *myriantha* 22; nitida 3; neglecta 7; Nutkana 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 21, 22, 24, 33, 34; Nutkana hispida 8; *parviflora* 3; pisocarpa 7, 10, 11, 14, 15, 16, 17, 19, 20, 21, 23, 24, 25, 33, 34; *rubifolia* 3; Sayi 2, 17, 26, 27, 28; Sayi *Bourgeauiana* 27; setigera 3; Sonomensis 25, 26; spithamæa 21, 24, 25, 26, 33; Woodsii 2, 11, 15, 16, 17, 18, 19, 21, 22

Rosenberg, O., work of 181

Rowlee, W. W., work of 75, 227, 234, 245

Rumex, a new 429

Russell, H. L., work of 225, 246

Rust, of asparagus 351; of pine leaves 433

Rydberg, P. A., work of 182, 429; "Flora of the Black Hills" 181; "N. Am. Species of Physalis" 422

S

Saccoglottis Amazonica 512

Salix, adenophylla 398; Barrattiana Tweedyi 268; candıda 398; candida hybrids 75; cordata × sericea 392; discolor 398; incana 398; *Missouriensis* 392, 394; petiolaris 398; sericea (cordata ×) 392

Salts, toxic action of dilute 81, 125

Salvinia natans 249

Sargent, C. S., personal 76, 271

Sargent, Ethel, work of 426

Sassafras 161; officinale 164; *Sassafras* 164

Satyrus *rubicundus* 384

Saxifraga, new species 344; Small on 428

Schenck, H., personal 191

Schizæa pusilla 247

Schrenk, H. von, work of 243, 249

Schwendener, interview with 251
Scirpus camptotrichus 238
Scribner's "Grasses" 430, 502
Scrophularia leporella 344
Selaginella cuspidata 504
Senecio, new species of 504
Section cutting 306
Sedum, new species of 344, 429
Seeds, dissemination of 185, 348; effect of size and weight 424
Sensitive plants 293
Sequoia 349
Sesamum glands 70
Sex organs, of Cystopus, 424; reduced or metamorphosed 68
Sexuality, of fungi 301; of Ptilota 373
Shattuck, S. G., work of 77
Shrubs, ecology of African 506
Sidalcea Hendersoni 489
Simblum 379, 390; *ptilidiatum* 390; *rubescens* 390; sphærocephalum 390
Sisymbrium, altissimum 253; *incanum* 429
Slide with binding posts 471
Small, J. K., work of 79, 240, 344, 428, 429
Smilax, ecirrhata 161; herbacea 161
Smith, Anna A. 35, 402; personal 431; work of 235
Smith, Donaldson, work of 428
Smith, J. G., "Fodder and forage plants" 343
Smut, fungicide for 238; a new 413
Solidago, Canadensis 249; new species of 504
Sophia 429
Sparassis Herbstii 430
Spatholirion 344
Species-making, philosophy of 221, 454
Spermothamnion, procarps and cystocarps of 370
Spondylothamnion, procarps and cystocarps of 370
Sporangia 226
Spores, of fungi 301; production of, in Coleosporium 441; in Rhodophyceæ 35.
Sporocarp of fungi 301
Sporophyll transformation 220
Sporotrichum globuliferum vs. chinch bugs 424
Spraying of plants 249
Staining 37, 306
Staminodia 69
Stapelia 161
Starch in herbs 181
Stellaria obtusa 488
Stem anatomy of Onagraceæ 229
Sterculiaceæ, new genus of 168
Stigma of Arisæma 234
Stomata of pine leaf 436
Stone, G. E. 258
Stoneman, Bertha, work of 226
Strasburger-Noll-Schenck-Schimper's "Lehrbuch der Botanik" 178
Stuntz, S. C. 503
Sunflowers, hybrid 248
Swingle, W. T., personal 430
Symbiosis 75
Symphipappus 182

T

Taxonomy of monocotyledons 507
Teaching, botany for secondary schools 493
Technique 37, 65, 66, 245, 306
Tecoma, two forms of 429
Teichospore, 234, 307
Teichosporella 316
Teleutospores of Coleosporium 441
Tendrils, mechanism of curvature 243, 427, 505
Teratology and heredity 345
Tetraplodon, mnioides 244; symbiosis 75
Thalictrum, dioicum 241; Fendleri 241
Thompson's "Ligulate Wolffias" 60
Thuya 183; *excelsa* 184; *sphæroidea* 184
Thysanella and Polygonella 240
Tissue systems of fungi 510
Tobacco, chemical analysis of 424; exchange 191
Toumey, J. W. 253; work of 429
Toxic action of salts 81, 125
Tracy, S. M., personal 271; work of 75, 241, 502
Trécul, Auguste, death of 432
Trelease, Wm. 193; personal 75; "Juglandaceæ of the United States" 59
Treub, M., personal 190
Transpiration 503; excessive 446
Trianea, hairs of 133
Trichogyne, of Griffithsia 36; of Ptilota 362
Trichomanes Petersii 228, 410, 412; radicans 412
Trichophores of Griffithsia 35
Trichostomum **indigens** 50
Trillium, abortive buds of 402; erectum 233; erythrocarpum 493; grandiflorum 403; recurvatum 233; sessile 235
Trimen, Henry, death of 431
Trophy, definition of 68
Tropidocarpum fruit 345
True, R. H. 81
Turgor 249, 250; and growth 243
Turnips, disease of 503
Type specimen, what is a ? 241

U

Ulota crispula **dolosa** 51
Underwood, L. M. 255, 407; work of 222, 228, 232, 235, 429.
Uredineæ 301
Ustilagineæ 301, 413

V

Valeriana **Columbiana** 489
Vanderbilt library on forestry 191
Variation in Rosa 4
Verbenaceæ, new 182
Vermicularia, 226
Viburnum 249; **Demetrionis** 167; dentatum 166; molle 166; Opulus 69; pubescens 166
Vicia Faba, turgor 243
Vilmorin, H. de, personal 76; "Le Chrysanthème" 341
Vines, S. H., work of 503
Violets, work on 76
Vitex Hemsleyi 183
Volutella 226
Vries, Hugo de, personal 512; work of 345

W

Wager, H., work of 426
Waite, M. B., personal 350
Ward, L. F., work of 348
Warea, revision of 429
Warming's "Plant Geography" 173
Washington, plants of 488
Water, ascent of 183; excretion by leaves 503; loss of causing leaf fall 446; movements of 503; relation to hardiness 424; relation to vegetation 424
Waters's "Erysipheæ of Riley Co., Kansas" 501
Webber's "Pine-apple industry" 180
Weiss, F. E., work of 75
West, W. and G. S., work of 75
Westermaier, M., personal 350; "Compendium of general botany" 176
Wettstein, Richard von 401
Wiegand, K. M., work of 75, 247
Weisner, J., work of 67
Williams, Thos. A., personal 75
Willis, J. C., personal 190
Willkomm's "Pflanzenverbreitung iberischen Halbinsel" 63
Woodsia obtusa 409
Woodwardia areolata 409
Wounds, healing of 77
Wright, J. S., personal 430
Wyethia amplexicaulis 491

X

Xanthophyll, crystallization of 66
Xanthoxylum Americanum 155, 162
Xeroplana 182
Xyphosandra 344

Y

Yeatesia 429

Z

Zea Mais 126; vascular bundles 227
Zimmermann, A., personal 350